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## Cleaning Streets by Flushing.

One of the most interesting reports on municipal affairs made in a long time was summarized in this journal on Feb. 22. It was written by Messrs. H. deB. Parsons, Rudolph Hering and Samuel Whinery and discussed the methods of street cleaning and waste disposal best adapted for the various boroughs of New York City. By referring to that article it will be seen that the commission strongly favored a method of cleaning streets which utilizes flushing. Until a few years ago proposals to follow this method in New York were vigorously opposed on account of the limited capacity of some of the old sewers, but since then many of the sewers have been reconstructed and experience during the past year has shown that flushing the streets does not put too great a strain on the capacity of these conduits. Under the circumstances, therefore, it is not surprising that this method of street cleaning finds favor, as it is approved in other cities, some of which have used it for many years. There is nothing in municipal affairs which appeals more strongly to the average citizen than the condition of the streets, and anything that will insure their greater cleanliness is certain to be received with approval, which is likely to be increased when a more general appreciation of one important condition of street cleaning exists. Any kind of dirt or litter on the streets is annoying, but there is one kind which is far more dangerous from the point of view of sanitation than any other. It is the very fine material which assumes the form of sticky mud during wet weather and light impalpable dust in dry weather that is most to be feared. It is this which carries the germs of disease and is a menace to health. In spite of this fact, however, the street cleaning ordinarily done removes only a part of this material, being directed mainly to the removal of the coarser dirt and litter. The amount of this dangerous dust left after regular cleaning is astonishing; the commission made careful examinations which showed that from 0.1 to 4.8 cu. ft. of it remained on each 1000 sq. yd. of pavement after it had been swept. The difference in effectiveness of hand sweeping and machine sweeping was apparently not very great, although the former was a little more thorough. There was, of course, a very marked difference between the quantities of dust left upon pavements of various kinds. Measuring the amounts by weight, it was estimated that there is anywhere from 50 to 800 per cent. more dust on block pavements than on asphalt. From the sanitary point of view, therefore, it is most desirable to employ some method of cleaning which will remove more of this residue of dangerous dust than ordinary sweeping.

In order to have positive data upon which to base its conclusions, the commission made a careful investigation of the cost of street cleaning by various methods. The analysis included the cost of complete outfits, repairs and depreciation upon them, interest and the wages of all the men employed. An analysis of this sort showed that it would cost 31.7 cents to sweep 1,000 sq. yd. of pavement with machines, 28.1 cents by hand and 25.1 cents by flushing the streets with jets of water thrown from a fan-shaped nozzle discharging not more than 150 gal. per minute. In reaching these conclusions as to cost, every item which might legitimately be included was considered. Repairs and depreciation on the hose and nozzles were figured at 150 per cent. per annum, for instance, and the water was estimated at $90 per 1,000,000 gal. It is believed that the conditions are correct for New York City and that flushing when properly conducted is the cheapest method of cleaning the streets, provided the coarse litter is first removed in some other manner.

In favor of flushing, it is stated that when the work is properly done not only the coarser fragments of street dirt, but the dust in dry weather and the mud in wet weather are effectually removed. Street sprinkling becomes unnecessary where street flushing is done. If it is conceded that dust and mud are the most objectionable and damaging forms of street dirt, then it must also be conceded that flushing is the most effective way so far discovered of cleaning city streets. The work can be done at night, when it will be of least inconvenience to the public, as in the case of machine sweeping. It seems to be overlooked that a normal function of storm-water sewers is to carry away the surface water and any detritus it may contain, and where the street cleaning is imperfectly done, every hard rain necessarily washes the accumulated street dirt into the sewers. The commission believes that the water jets will not injure any well-constructed block pavements and will certainly cause no trouble on sheet asphalt. The use of fire hydrants by the employes of the street cleaning department should, of course, be so conducted that there is no chance of injuring the hydrants. The great difficulty attending any such method of cleaning at the present time is the possible scarcity of water, but the chief engineer of the Department of Water Supply, Gas and Electricity, told the commission that a constant supply of 1,000,000 gal. per day, which is the amount considered necessary for the preliminary flushing experiments in Manhattan, Brooklyn and the Bronx, could be spared except in times of unusual scarcity. In a few years the projected additional supply from the Catskills will be available, and for a long time to come thereafter ample water for street cleaning purposes is assured.

This method of cleaning is important mainly on account of its removing the fine dust previously referred to. There is a great mass of litter which accumulates during the daytime that can be removed to advantage by the regular system of hand control. Moreover, a large amount of refuse is thrown on the streets contrary to law, and if the Police Department can be persuaded to enforce these laws the work of street cleaning will be materially cheapened. One experienced director of such work estimates that the annual cost of street cleaning is increased as much as $400,000 on account of this controllable litter, while another estimates that 40 per cent. of the refuse collected as street sweepings comes from these sources which are contrary to law. By keeping this refuse off the streets, the work of the hand sweepers will be reduced and each of them can cover a larger territory than at present. Moreover, if the streets are washed down every night the work of the hand patrol will be much less than at present, since flushing will leave cleaner pavements than machine sweeping. The commission makes a very convincing argument for this method of cleaning and it is to be hoped that it will be tried. Their advice is conservative; they do not claim that it is the last word on the subject, and they recommend simply giving the system a thorough trial on a sufficiently large scale and with accurate cost records kept all the time, so that just what can be done will be definitely known. In view of the many complaints against the condition of the streets a year ago, it would certainly seem that the city authorities are warranted in giving the recommended method a thorough trial.

## Revision and Approval of Proposed Plans by Engineers.

Although engineers are now usually retained from the inception of proposed works of magnitude, yet there are frequently cases in which the projectors of technical undertakings secure at least the initial plans from contractors, and there are even cases not so very infrequent in which contracts for relatively large pieces of construction, such as the substructures and superstructures of bridges, are awarded even prior to securing the services of an engineer. Under such conditions the engineer urgently needs tact and good sense as well as purely professional qualifications, for it usually happens that he must revise the original plans, sometimes to such an extent as to amount to redesigning, before working plans of any part of the structure can be developed. The difficulties of such a situation are obviously greatly enhanced by the written contract, and it sometimes occurs that the latter itself must be recast. These are by no means imaginary cases; there are a few in evidence at present within no very great distance of the City of New York.

Again, without including the more difficult cases of the class cited above, there are, comparatively speaking, many of a less troublesome character to deal with. They arise from the disinclination of the owner, for one reason or another, to secure the services of an engineer at the very inception of the undertaking. Builders or contractors are invited to submit their own designs for a steel bridge and foundation, or some other similar construction, with estimated costs, and usually in a competitive way. A large Eastern city adopted this very procedure a few months ago and has since suffered the consequences. After such competitive designs and estimates have been submitted under the most meager, general and imperfect specifications, an engineer may be called in, either before or after awarding the contract, to examine the various plans, estimates and sometimes even specifications, and report upon their efficiency and sufficiency. In discharging this duty under probably the most embarrassing conditions which can arise to disturb a professional man, he is expected to make a critical examination both of the main features and all the details of every part of the work contemplated to be done. Although this work is nominally the scrutiny of plans already submitted, it is practically a redesign of every part of the structure, not with the freedom of an original design of his own, but under the constraint of an already formulated design cramping and limiting his operations. He naturally desires to preserve all that is practicable of the proposal before him, however incomplete or ill-considered it may be. At the same time he must keep constantly in view the interests of his client and secure them absolutely against all prejudice or detriment. In the case of a steel construction like a bridge superstructure, it may be, and usually is, comparatively simple to reach by revision satisfactory results without radically changing in all respects what has been submitted, especially if the contractor or builder is accustomed to the execution of contracts for high-class work; but the situation is frequently radically different if the foundations of a bridge are involved, particularly where there are a number of foundations to be built in deep, difficult and varying material. The inexperience of the contractor's designer and frequently the insufficiency of data, coupled with the short and superficial study given to the matter under such conditions, almost invariably produce fundamentally defective designs and make it necessary for the engineer who subsequently takes up these questions in a more deliberate manner to change entirely the plans and procedures contemplated in the original proposal. He is fortunate if he finds himself able to clear up such complicated circumstances and their obscurities and contradictions and secure final working plans and procedures satisfactory both to his client and to the contractor. While such results have propably been attained in many cases, there are many more in which these conditions have led not only to constant friction and continuous trouble during the progress of the work, but to active litigation after the completion of the contract.

All these features of such chaotic and pernicious methods are sufficiently troublesome from a purely administrative or business point of view, but there are other ways in which they give to the engineer even more serious difficulty, if possible, than in the actual execution of the contracts, as in questions pertaining to his professional responsibility. It may be perfectly obvious that when an engineer, responsible for the character and conduct of his work, accepts and by official approval adopts as his the plans, whether general or detailed, of another, he becomes legally and morally responsible for them, as if they were originally his own. This fact should, of course, cause every responsible engineer to scrutinize, criticise and revise plans and processes submitted to him for his approval absolutely without any other thought or feeling than to make them precisely what they would have been had he originated such plans. Any engineer who has had such professional duties to perform will easily understand how difficult and yet how necessary it is to follow such a course. A contractor or builder may, with perfect propriety, have nursed a weak or doubtful project in its earlier stages when its success was at best extremely questionable. In doing this he may have contributed the results of his experience and the ability of his engineering organization to bringing the project to a successful culmination. While his plans and specifications or other parts of the enterprise as a whole may not be best suited to the project in its final shape, they probably have possessed considerable merit, and when the time has come for an engineer to take charge of the enterprise for his client, it is no more than right and proper for him to recognize such merit as the undertaking in all its features may possess, and that is undoubtedly what every fair-minded engineer would do. At the same time, he must be guided most scrupulously by the fact that his official approval places the whole responsibility of the work upon him and essentially relieves the original designer or proposer of responsibility for results. In the case of one prominent and careful American engineer, after a number of such experiences, he has adopted the procedure of cancelling practically everything proposed to him and beginning a fundamentally new design irrespective of what had been submitted. This procedure seems unnecessarily wasteful of time and effort, but it certainly possesses the eminent merit of clearing the situation of every obscure and doubtful point as to responsibility.

No engineer, either in view of his responsibility to his client or in fairness to himself, can afford to treat such matters of derived responsibility in any but the most serious and radical manner. He should always recognize the responsibility of specifications submitted by others but assumed by himself. They carry responsibility directly home to him, and his revision of such plans and specifications should be so drastic, if necessary, as to justify that responsibility, no matter what the consequences may be to any other obligations whatever; the latter may be adjusted both by tact and good sense, but there can be no cure for defective or ill-assumed professional responsibility.

## The Inland Waterways Report.

The report of the Inland Waterways Commission, transmitted to Congress last week by President Roosevelt, is not a complete report, but merely a preliminary outline of the wide range of problems presented by any project for the complete utilization of national water resources. There seems, however, something of a misunderstanding regarding the nature of the report. In the message of the President submitting it to Congress, it is stated to represent the "mature judgment of a body of men exceptionally qualified by personal experience and knowledge of conditions throughout the United States to understand and discuss the great problem of how best to use our waterways in the interest of all the people." The report itself does not bear out this statement that it is the mature judgment of the Commission. It is signed by eight members of the Commission, who state, near its conclusion, that "the Commission is, however, fully aware of the incompleteness of this report, and is desirous of continuing investigation and discussion with a view to further action." In addition to this statement there is a supplementary report by Gen. Alexander Mackenzie, Chief of Engineers, U. S. A., who dissents from a portion of the statements of his colleagues, and says, "until this Commission shall have fully carried out the duties allotted to it and prepared a comprehensive plan for the improvement and control of the river systems of the United States, or at least until such work is more advanced, and results more thoroughly considered, I believe a recommendation for so radical a departure in the methods of planning and executing the improvement of waterways as that proposed is at least premature." These statements by the members of the Commission are mentioned prominently in this place because they indicate such a project as that submitted to them by the President demands careful consideration of every step taken. It is not surprising that the Commission desires to continue its important work, for its members are men of wide responsibilities, and the time they have been able to devote to the problems has manifestly been too limited for them to complete their consideration of it.

The results accomplished by them to date are summarized in a statement of "facts" which is reprinted elsewhere in this issue, a number of recommendations, and a statement of the inquiries still in progress when the report was written. Probably most of the readers of this journal will agree with the statement of "facts" in the main, although there are a good many who will vigorously oppose as incorrect some details in it. There is, moreover, a spirit of hostile criticism of railroad and hydro-electric plants which is far too sweeping in its general condemnation of such companies to find a place properly in any state document. Thousands of people in moderate circumstances have invested a part of their savings in stocks and bonds of the railroad and hydro-electric companies of this country, believing that these corporations were conducting a useful business in a legitimate manner. The disturbing influence on the investors of the country of criticisms like those in this report is deplorable. This journal is a hearty believer in the control of all public resources, so that in their utilization the people at large shall share with the companies that develop them in the benefit of the work. It also believes that the co-ordination of the varied developments of the national water resources by the harmonious work of the various departments which are concerned is something to be warmly supported. It does not see any reason, however, for approaching the subject in a spirit of general hostility to the companies that have already done much to develop these resources. Because a few of them may have been badly managed, all should not be condemned.

The initial recommendation of the Commission is that hereafter plans for the improvement of navigation on inland waterways, or for any use of these waterways in connection with interstate commerce, shall take account of the purification of the waters, the development of power, the control of floods, the reclamation of land by irrigation and drainage, and all other uses of the waters or benefits to be derived from their control. In order to carry out this recommendation it is further suggested that Congress should authorize the President to organize a national waterways commission to bring into co-ordination the Corps of Engineers of the army, the Bureau of Soils, the Forest Service, the Bureau of Corporations, the Reclamation Service, and other branches of the public service in so far as their work relates to inland waterways. Although the language of the recommendation is not clear, it apparently is intended to turn over to this commission the entire charge of the improvements of rivers and harbors, as well as the various other methods of developing water resources.

Evidently this is the view of the matter held by the President, for he states in his message that "the first condition of successful development of our waterways is a definite and progressive policy. The second is the concrete general plan, prepared by the best experts available, covering every use to which our streams can be put. We shall not succeed until the responsibility for administering the policy and executing and extending the plans is definitely laid on one man or group of men who can be held accountable." In view of the present Commission's own statement concerning the incomplete nature of its report, it certainly appears that any such action at this time is premature. The work of the Reclamation Service, the Forest Service and other bureaus of the administrative departments is sufficiently well organized to run along in its present course for a number of years without any serious loss to the public. This journal fully believes, with Gen. Mackenzie, that various aspects of the inland water conservation program outlined by the majority of the Commission, important and worthy of consideration as they may be, are not so necessarily associated with the subject of channel improvements and interstate commerce as most of the members of the Commission assume. When some of the suggestions of the Commission are carefully considered, it will be found that they involve a co-operation of the federal, state, county and municipal authorities in a most perplexing degree, and any project which associates these interests before the legal methods of accomplishing such an association are very carefully considered is likely to prove a legal failure.

While these criticisms of the report may appear pessimistic, The Engineering Record believes that the work has been of the highest value and trusts that it may be continued until the Commission has had ample time to weigh carefully all of the main factors of the great problem presented to it. The waterways of the country must be materially improved, the irrigation enterprises of the Reclamation Service should be extended, and some kind of control should be exercised over private undertakings of this nature so that work of a minor character may not interfere with great national enterprises; it is certainly desirable to check the pollution of interstate streams, and to provide some means for utilizing them to a greater extent than our laws now justify; the prevention of floods is a problem of vital importance in many sections of the country, while from Maine to Washington the development of water power is everywhere attracting attention. This range of subjects is too vast, however, to be committed prematurely to any one commission or any one man. The relative importance of its different features is not fully understood as yet, but a great deal of good can undoubtedly be accomplished by some kind of an organization which will bring together for mutual discussion the various departmental bureaus now interested in the work. It would be a pity, however, to overturn the excellent organizations which have control of the river and harbor improvements and the national irrigation works, and entrust these great operations to some new bureau. It is impossible to see now what could be accomplished by a new organization which cannot be accomplished by a method of coordinating the work of the different existing bureaus, although further study by the Commission, particularly if it be given funds to engage expert assistance, may indicate possibilities now unrecognized. The tremendous importance of our public works makes it hazardous to take any action regarding these undertakings based on a report which those signing it term incomplete. It has been repeatedly demonstrated that the best results can only be obtained when plans for the main elements are based on a thorough study of the governing conditions.

## Notes and Comments

ANOTHER TUBE of the East River tunnel of the Pennsylvania improvements at New York has had its headings joined. It is tube A and its headings met at 3:30 p. m. March 3, their alignment being out only a small fraction of an inch. The first of the four tubes, D, had its headings joined Feb. 21.

PITOMETER SURVEYS for the detection of water waste in Washington are carried on by a special force of seven men and two horses and wagons with five pitometers having photographic recorders. The work is done by dividing the area under investigation into comparatively small districts, each of which can be supplied by a single main, placing a permanent pitometer connection on this main and measuring the flow of water by the regular method when this instrument is employed. By successively cutting off the several parts of the small district the amount of water flowing to these parts is ascertained, and by continuing the process waste and leaks are located and measured. The work was organized early in the last fiscal year and during that period checked the waste of 914,000 gal. daily at a total expense of $10,600 for all labor and materials.

ANOTHER EAST RIVER BRIDGE must be constructed before long if the traffic between Brooklyn and Manhattan continues to increase in the future as in the past. The opening of the tunnel between the two boroughs has diverted so little traffic from the old Brooklyn Bridge that it is now certain the Manhattan Bridge will be unable to answer the reasonable demands of those who have to cross the East River toward and from the lower end of Manhattan. The carrying capacity of the old Brooklyn Bridge can be considerably increased by adding a new roadway and stiffening trusses, and unquestionably this will be done before many years. It is evident, however, that another structure not far from it must be erected shortly, and it is gratifying to learn that the Department of Bridges of the city has already let contracts for making borings to determine the best site for the substructures of such a new bridge.

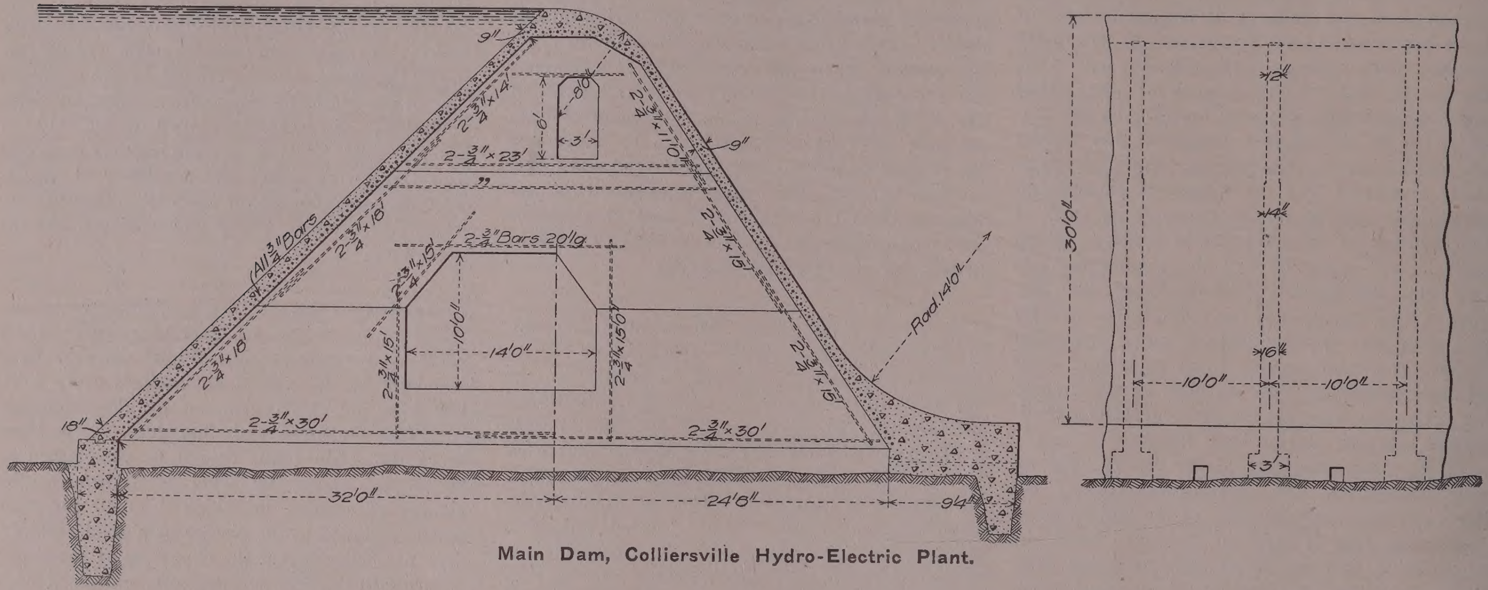
THE NEW RAIL SPECIFICATIONS of the Pennsylvania R. R., which were outlined in this journal on Feb. 15, contain one requirement which has been found particularly useful by the Philadelphia & Reading Ry. This is the marking of each rail with a letter indicating the portion of the ingot from which it came. The Philadelphia & Reading Ry. has marked its rails in this way for seven years, which has enabled that company to obtain some decidedly interesting information concerning the cause of the majority of failures of rails in service. Two-thirds of all the rails, bought within this time, which fail are rolled from the top of the ingot, and the next largest percentage of failures is among the rails from the bottom of the ingot. Actual records like this are of so much more value than any theoretical discussion of the subject that the information to be obtained from the records of the new rails for the Pennsylvania System will undoubtedly prove of considerable influence on the rail industry.

THE CONCRETE BLOCK SPECIFICATIONS adopted at the recent convention of the National Association of Cement Users, printed elsewhere in this issue, deserve careful consideration. They were drafted by a committee of which Mr. E. S. Larned, of Boston, is chairman, and are the result of a painstaking inquiry among those interested in the concrete block industry, as well as among engineers and architects. The use of hollow concrete building blocks is extending so rapidly that regulations concerning them are desirable for the protection not only of the public, but also of those makers of blocks who produce only a good product. Blocks of this nature are an excellent building material not only for houses but also for power plants and shops, and engineers who have made them for use on their own buildings have generally expressed entire satisfaction with the results, both as regards the character of the blocks themselves and the cost of the walls built up with them. On the other hand, there are many block machines being used by people who know nothing whatever about the proper manipulation of materials or even about their selection. As a result, blocks are being sold which will destroy confidence in the infant industry unless steps are taken to prevent such worthless materials coming on the market. The best way to secure such protection against inferior blocks is to pass and enforce such regulations concerning them as are outlined in the standard rules of the National Association. Probably these regulations are not the last word on the subject; they represent, however, a conscientious endeavor to be fair to the maker and purchaser of blocks, and until something better has been suggested, no city or town can go astray which adopts and enforces them.

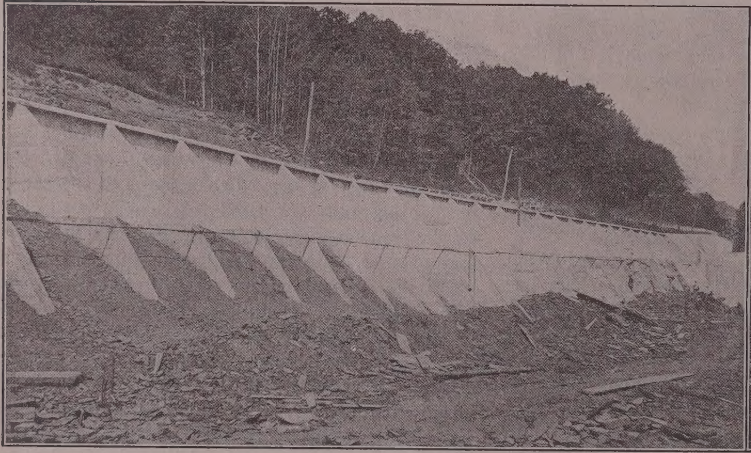
THE ROAD PROBLEM in the Philippines is discussed in the report of Secretary Taft on his recent visit to the island. While highways have been built by the central government every year, they have not been kept up by the municipal authorities entrusted with that duty. Experience shows that such roads cannot be maintained in the tropics except by what is known as the "caminero" system, in which a small piece of road is assigned to the charge of a road repairer. Mr. Taft believes that the character of the maintenance will develop as the people entrusted with it develop, because the people can keep up the roads if they will, and it is not until they have a considerable sense of political responsibility that they are likely to sacrifice much to maintain them. He states that while the townspeople seem to appreciate fully the value of better highways, when it comes to exerting themselves for the purpose of securing this great benefit they have not thus far nerved themselves to the sacrifice. Many miles of good roads have been constructed and turned over to the municipalities for maintenance, with the result that in one or two years the torrential rains have turned the roads into nothing but quagmires because no work of maintenance was done on them. One difficulty is that the traffic on the highways is largely by the carabao or ox-cart with a rigid axle and solid wheels having rims so narrow that they cut like a knife into any road over which they travel. While laws have been passed imposing a penalty for using wheels with tires of less than a certain width on improved roads, the enforcement of such laws in rural towns seem to be beyond the ability of the authorities. Secretary Taft states that local officials have been loath, when depending for their continuance in office upon votes of their fellow-citizens, to enforce a law the wisdom of which they fully recognize, but the unpopularity of which they also know. In spite of these rather gloomy statements, the Secretary of War reports that highway improvements under the "caminero" system are likely to continue and be extended. The principle is now enforced rigidly that no bridge shall be constructed of anything but permanent materials and no road shall be built except in a manner which will enable local authorities to keep it in perfect repair with reasonable expense. Experience in the past has shown that inferior construction executed to meet apparently imperative demands and at nominally great economy is much more costly than if the original expense had been greater.

# THE COLLIERSVILLE HYDRO-ELECTRIC PLANT.

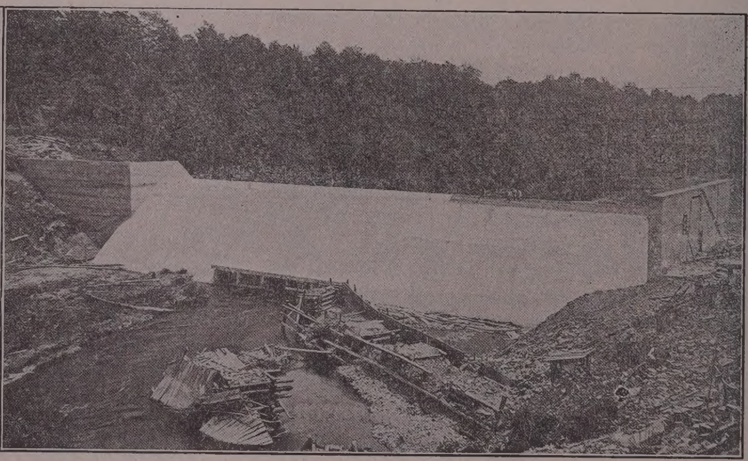
A power plant has just been put in service on the Susquehanna River near Colliersville, Oswego County, N. Y., to furnish power for the 65-mile line of the Oneonta & Mohawk Valley Railroad and for power and lighting purposes in adjacent towns and villages. The current is transmitted about 18 miles from the power house to Hartwick, N. Y., where the railroad company has a steam plant intended to be operated as an auxiliary to supply the deficiency in current which may occur from a diminished water supply for three months in the year.



Main Dam, Colliersville Hydro-Electric Plant.



Canal from Head Gates to Power House.



View of Down-Stream Face of Dam.

The plant consists essentially of a 520-acre reservoir, impounding sufficient water to carry the station through five or six days of scanty supply, a dam, canal, tail-race, buildings, and hydraulic and electrical installation. All the structures are of concrete and steel and all principal foundations are carried down to rock.

The dam is built across the river at right angles to its axis about 150 ft. upstream from the site of an old crib dam which formerly provided for the operation of a saw mill, indicated by dotted lines in the accompanying general plan. The new dam is of the Ambursen type, 200 ft. long on the crest, about 70 ft. wide at the base, 4½ ft. wide at the crest and 36 ft. high to the lowest part of the foundations, which are excavated through successive thin layers of shale and clay to a footing in solid shale about 6 ft. below the original bed of the river and 36 ft. below the flow line of the reservoir. The excavation was made without difficulty in open cofferdams. After the foundations were built at one end of the dam, the water was diverted from its original channel, and the foundations were built there also, enabling the structure to be completed except for a temporary sluice-way formed by openings left in the lower part of six panels near the middle of the dam.

The upstream face of the dam is provided, at the ends of the sluice-ways, with a full height offset in which there are vertical grooves for stop logs. After the other portions of the dam were concreted the sluice-ways were closed by completing the up and down stream faces, previously omitted to allow the temporary passage of water during construction. Stop logs were placed in the grooves, the flow arrested and the water impounded in the reservoir.

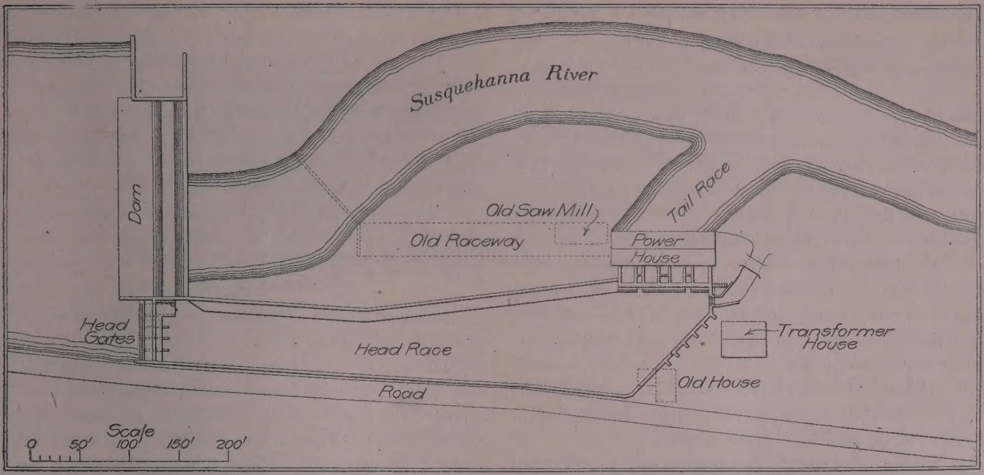
In order to provide against overflow on the stop logs when the dam was submerged, flash boards 18 in. high were set on the middle of the dam, over the sluice-ways, and were reinforced by sand bags. The lower end of the sluice-ways was protected by crib and stone cofferdams and the closing concrete was laid from the interior and lower face of the dam. The work was somewhat prolonged, and a sudden freshet raised the water in a few hours to 37 in. above the crest of the dam, demonstrating the wisdom of providing the flash boards, some of which were washed away together with the cofferdams on the downstream face.

The dam is reinforced with about 50 tons of ¾-in. round steel bars and contains about 2,000 cu. yd. of 1 : 3 : 4 concrete made with graded broken stone up to 2 in. in diameter and Helderberg Portland cement. The concrete was mixed in a machine located at one end of the dam and delivered by steel buckets handled by a Lidgerwood cableway on the axis of the dam, which was also used during excavation for the removal of the spoil.

The abutment at one end of the dam is a vertical concrete wall L-shape in plan, 3 ft. thick at the top and 5 ft. thick at the bottom, with a maximum height of 40 ft. from the lowest part of the foundation to the coping 6 ft. above the crest of the dam. The upstream face, about 70 ft. long, is parallel to the axis of the dam and has its footings, like those of the transverse wall, trenched down into shale rock. The concrete is reinforced with vertical and horizontal steel rods and serves as a curtain wall, being itself supported by filling on both sides.

At the opposite end of the dam the abutment is a similar concrete wall transverse to its axis, and not only forms a part of the head gate construction, but it is extended downstream continuous with the river wall of the forebay canal.

The canal is about 550 ft. long and its width increases from 60 ft. at the head gates to about 100 ft. at the power house. The bottom is excavated to shale rock and is not lined, but all seams were raked out and pointed with cement mortar, and there are concrete walls on both sides. One of them is comparatively light and is backed up solid against the shale hillside, while the other, about 20 ft. high on the river side, is proportioned to resist a maximum head of 12 ft., and has its footings carried down to a maximum depth of about 20 ft. below the bed of the canal. It has a



General Plan of Colliersville Hydro-Electric Plant.

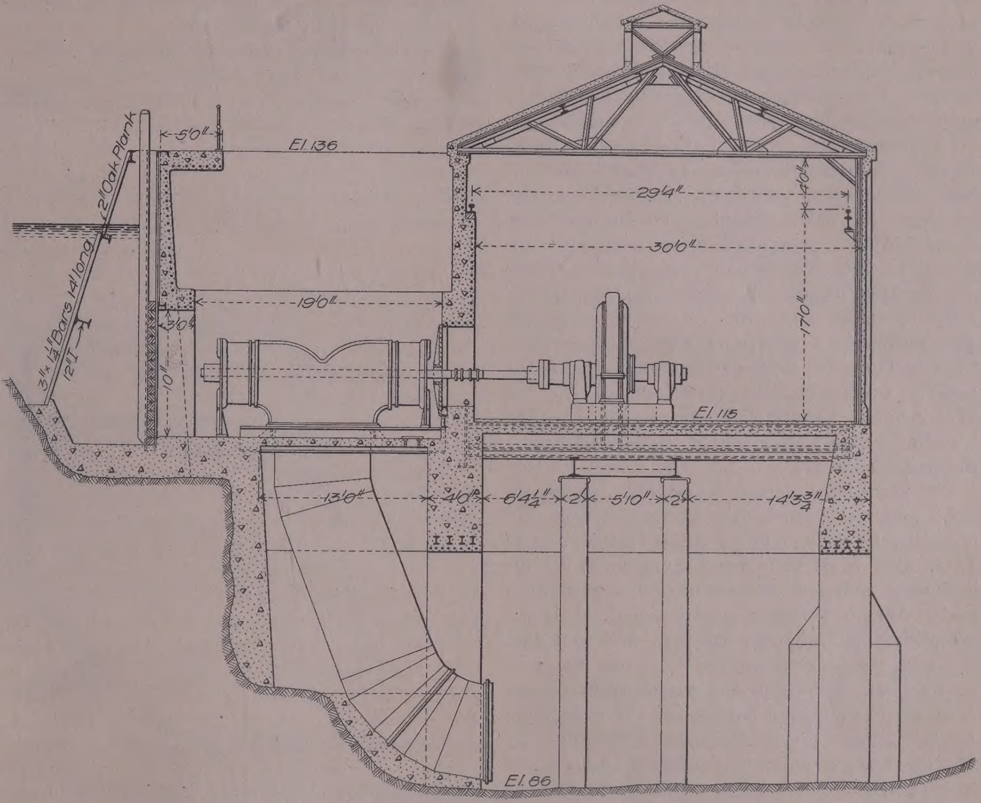
vertical face, is 8 in. thick at the top and 16 in. thick at the base and is strengthened on the river side by very wide triangular buttresses of reinforced concrete about 15 in. thick and 12 ft. apart on centers with their toes carried down to a maximum depth of 32 ft. below the crest of the wall and with the spaces between them partly back filled. A horizontal coping 18 in. wide is supported on the tops of the buttresses and forms a footwalk alongside the canal.

The lower end of the canal, just below the power house, is closed by a wall similar to the river wall and oblique to the axis of the canal, thus serving to deflect the water through the power house gate, adjacent to which there is a sluice-way 6 ft. wide and 10 ft. deep, which is primarily designed to be used as an ice chute. Normally it is closed with stop logs, which can be removed to allow all or a portion of the contents of the canal to be discharged between short concrete training walls and a channel excavated in the rock to the river below the power house.

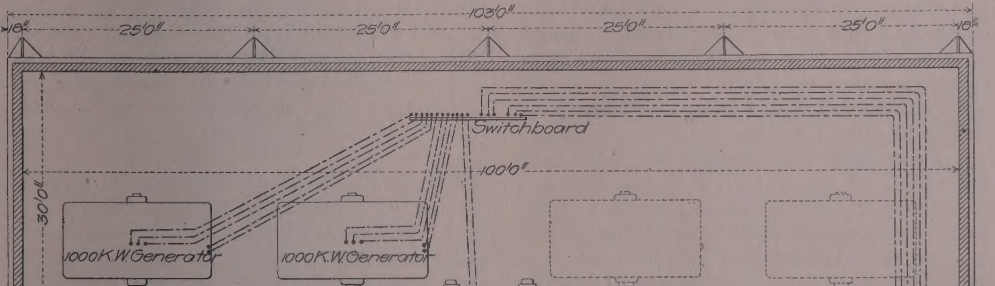
There are five head gate openings 10 ft. wide in the clear between reinforced concrete piers 18 in. thick and about 28 ft. long on the base. The downstream ends of these piers are seated on the rock bottom of the canal and the upstream ends are carried down about 5 ft. deeper and are seated on the concrete apron covering the floor of the forebay. The tops and parts of the upstream ends of the piers are connected by horizontal and inclined transverse slabs of reinforced concrete, forming working platforms and face walls for the operation and support of the stop logs and racks, as indicated in the sectional elevation. The rack is made with 3 x ¼-in. bars 10 ft. long, spaced 1¼ in. apart, supported at the top and bottom by concrete seats and stiffened intermediately by a horizontal 9-in. channel.

The stop logs 10 ft. 10 in. long have an 8 x 24-in. cross section made with 3 pieces of 8 x 8-in. timber splined together and secured by three ¾-in. eye-bolts with the nuts and eyes countersunk flush with the lower and upper edges of the logs and an oval recess about 10 in. long and 2 in. deep enclosing the eye to permit it to engage a hook on the hoisting tackle suspended from a trolley on a horizontal transverse I-beam 6 ft. above the working platform. The vertical grooves receiving the ends of the stop logs are lined with 9-in. channels with their flanges turned outward.

The 30 x 100-ft. power house has two main transverse foundation walls 4 ft. thick supported on arches of 20 ft. span, carried by 5-ft. piers seated on the shale rock of the tail-race bottom 44 ft. below water level in the canal. On the upstream side of the building there are five draft-tube pits with concrete lining which are floored with concrete slabs about 28 ft. above the bottom of the tail-race. The power house is of very simple construction with a 6-in. concrete floor slab about 16 ft. below the water level, which is supported on steel beams and girders. The concrete roof is carried by riveted steel trusses and the generator room is commanded by a 5-ton traveling crane of full span with its runway girder supported on wall columns built into the concrete and extended to carry the roof trusses. As the west wall of the power house is submerged and sustains a considerable hydrostatic pressure a false wall of cement mortar on wire lath was furred out from its inner face, leaving a 2-in. space for seepage and condensation which is collected in a drain at floor line and discharged into the tail-race.



Transverse Section through Power House.



Plan of Power House.

The 43 x 34-ft. transformer house is of similar construction except that it has no wall columns or traveling crane and that it is provided with a 9 x 15-ft. tower rising to a height of 16 ft. above the main eaves. The roofs and floors are reinforced with Clinton wire cloth and great care was taken to water-proof with tar the wall between the wheel pits and dynamo room.

The power house is equipped with two 1,600-h.p. horizontal turbines with a guaranteed efficiency of 80 per cent. They are designed to run at about 187 r.p.m. and are governed independently by improved governors. Two small exciter turbines have also been installed and provision is made for the future installation of two more large turbines. There has been connected to each of the main turbines an alternating current generator with a capacity of 1,000 kw., wound for 2,300 volts, 25-cycle, 3-phase. There are also two direct-current exciters, each of them capable of exciting both generators simultaneously.

The switchboard, 12 ft. 8 in. long and 92 in. high, has five panels of blue Vermont marble 2 in. thick with beveled edges, supported on an iron framework. Panels 1 and 2 each control one of the 1,000-kw. alternating current, 2,300-volt generators. Panel 3 controls the two exciters which are 30-kw., 125-volt, direct current, compound wound generators. Panels 4 and 5 each control a three-phase feeder to supply 2,300 volts current to a group of three 375-kw. transformers connected in delta. In the transformer house there are installed six 375-kw. high-duty, oil-insulated, water-cooled transformers, arranged in two groups of three each and connected in delta for three-phase operation. There are also two 16,500-volt, distant control, electrically operated, automatic oil circuit breakers. The turbine and governors were manufactured by the Holyoke Machine Co. and all of the electric equipment was manufactured by the Westinghouse Electric & Manufacturing Co. The traveling crane was manufactured by Manning, Maxwell & Moore.

The plant was designed for Mr. Henry W. Bean and associates by the Stevens-Hewett Engineering Co., Mr. Irving Cox, president, and in June, 1906, construction was commenced by the designers, acting as contractors on a percentage basis. When the work was nearly one-half accomplished and the expenditures indicated that the cost would overrun the estimates the first contract was abrogated and a new contract was executed by the same parties for the completion for a lump sum price. The firm of Wm. Barclay Parsons was appointed by the owner as engineers to supervise the completion of the work and the testing of the machinery, which is now in satisfactory operation. The work was completed under the direction of Mr. P. S. Tainter, representing the Stevens-Hewett Engineering Co., and the tests were conducted by Mr. H. M. Brinckerhoff, mechanical and electrical associate of Mr. Wm. Barclay Parsons.

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The Block Signal Equipment of the Pittsburg & Lake Erie Railroad has been completed over practically its entire mileage, there being 30.8 miles of four-track line, 8.4 miles of three-track line, and 99.1 miles of double-track thus equipped, which is the equivalent of 346.6 miles of single track. The installation comprises a total of 955 signal blades, a large proportion of which are carried on signal bridges that cover the four-track divisions of the system, and such other portions as are expected to be increased to four tracks. The signals are operated on the normal clear system, and track circuits are used instead of overhead wires for the signal circuits, with marked success, the signal circuits having been found since the beginning of operation to be entirely uninfluenced by climatic or other external conditions, especially lightning. The signal equipment has been furnished by the Union Switch & Signal Company; construction began about eight years ago, and the system was completed to its present stage during last season.

## Standard Rules and Regulations Governing Concrete Hollow Block

Adopted by the National Association of Cement Users.

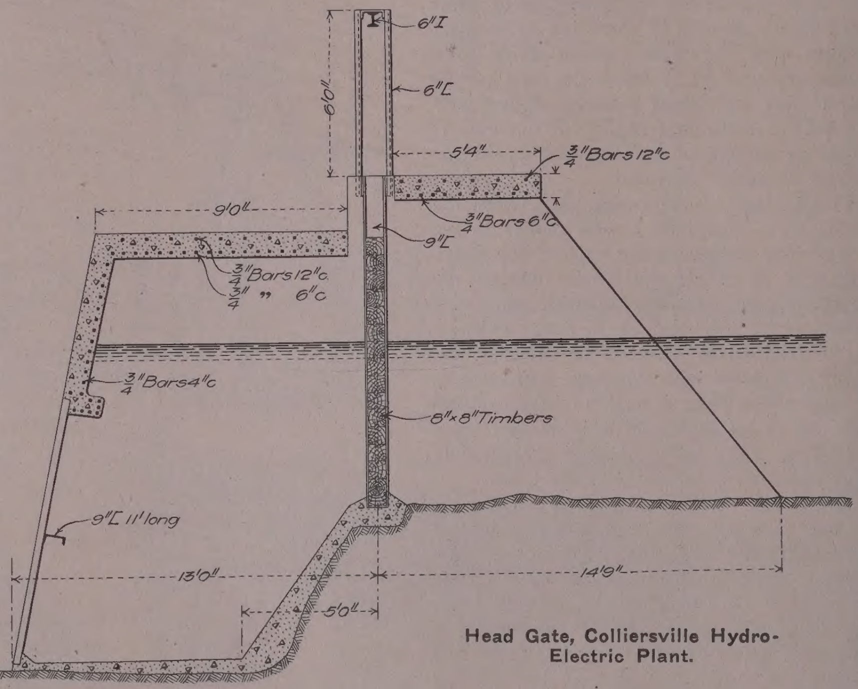
Concrete hollow blocks made in accordance with the following specifications, and meeting the requirements thereof, may be used in building construction, subject to the usual form of approval, required of other materials of construction, by the Bureau of Building Inspection.

1. Cement.—The cement used in making sand blocks shall be Portland cement, capable of passing the requirements as set forth in the "Standard Specifications for Cement," by the American Society for Testing Materials.

2. Sand.—The sand used shall be suitable siliceous material, passing the ¼-in. mesh sieve, clean, gritty, and free from impurities.

3. Stone or Coarse Aggregate.—This material shall be clean broken stone, free from dust, or clean screened gravel passing the ¾-in., and refused by the ¼-in. mesh sieve.

4. Unit of Measurement.—The barrel of Portland cement shall weigh 380 lb. net, either in barrels or sub-divisions thereof, made up of cloth or paper bags, and a cubic foot of cement shall be called not to exceed 100 lb. or the equivalent of 3.8 cu. ft. per barrel. Cement shall be gauged or measured either in the original package as received from the manufacturer, or may be weighed and so proportioned; but under no circumstances shall it be measured loose in bulk.



**Head Gate, Colliersville Hydro-Electric Plant.**

5. Proportions.—For exposed exterior or bearing walls:

(*a*) Concrete hollow blocks, machine made, using a semi-wet concrete or mortar, shall contain one part cement to not exceeding three parts sand and to not exceeding four parts stone, of character and size before stipulated. When the stone be omitted, the proportion of sand shall not be increased unless it can be demonstrated in each case that the percentage of voids and tests of absorption and strength allow greater proportions with equally good results.

(*b*) When said blocks are made of slush concrete in individual molds and allowed to harden undisturbed in same before removal, the proportions may be one part cement to not exceeding three parts sand and five parts stone, but in this case also, if the stone be omitted, the proportion of sand shall not be increased, except as specified in (*a*).

6. Mixing.—Thorough and vigorous mixing is of the utmost importance.

(*a*) Hand Mixing. The cement and sand in correct proportions shall first be perfectly mixed dry, the water shall then be added carefully and slowly in proper proportions, and thoroughly worked into and throughout the resultant mortar; the moistened gravel or broken stone shall then be added, either by spreading same uniformly over the mortar, or spreading the mortar uniformly over the stones, and then the whole mass shall be vigorously mixed together until the coarse aggregate is thoroughly incorporated with and distributed throughout the mortar.

(*b*) Mechanical Mixing. Preference shall be given to mechanical mixers of suitable design, and adapted to the particular work required of them; the sand and cement, or sand and cement and moistened stone shall, however, be first thoroughly mixed before the addition of water, and then continued until the water is uniformly distributed or incorporated with the mortar or concrete. Provided, however, that when making slush or wet concrete (such as will quake or flow) this procedure may be varied with the consent of Bureau of Building Inspection, architect or engineer in charge.

7. Molding.—Due care shall be used to secure density and uniformity in the blocks by tamping or other suitable means of compression. Tamped blocks shall not be finished by simply striking off with a straight edge, but, after striking off, the top surfaces shall be troweled or otherwise finished to secure density and a sharp and true arris.

8. Curing.—Every precaution shall be taken to prevent the drying out of the blocks during their initial set and first hardening. A sufficiency of water shall first be used in the mixing to perfect the crystallization of the cement, and, after molding, the blocks shall be carefully protected from wind-currents, sunlight, dry heat or freezing for at least five days, during which time additional moisture shall be supplied by approved methods, and occasionally thereafter until ready for use.

9. Ageing.—Concrete hollow blocks in which the ratio of cement to sand be one-third (one part cement to three parts sand) shall not be used in the construction of any building until they have attained the age of not less than three weeks.

Concrete hollow blocks in which the ratio of cement to sand be one-half (½) (one part cement to two parts sand) may be used in construction at the age of two weeks, with the special consent of the Bureau of Building Inspection and the architect or engineer in charge.

Special blocks of rich composition, required for closures, may be used at the age of seven days with the special consent of the same authorities.

The time herein named is conditional, however, upon maintaining proper conditions of exposure during the curing period.

10. Marking.—All concrete blocks shall be marked for purposes of identification, showing name of manufacturer or brand, date (day, month and year) made, and composition or proportions used, as, for example, 1-3-5, meaning one cement, three sand and five stone.

11. Thickness of Walls.—The thickness of bearing walls for any building where concrete hollow blocks are used may be 10 per cent. less than is required by law for brick walls. For curtain walls or partition walls the requirements shall be the same as in the use of hollow tile, terra-cotta or plaster blocks.

12. Party Walls.—Hollow concrete blocks shall not be permitted in the construction of party walls, except when filled solid.

13. Walls—Laying of.—Where the face only is of hollow concrete block, and the backing is of brick, the facing of hollow block must be strongly bonded to the brick either with headers projecting 4 in. into the brick work, every fourth course being a heading course, or with approved ties; no brick backing to be less than 8 in. Where the walls are made entirely of concrete blocks, but where said blocks have not the same width as the wall, where not otherwise sufficiently bonded, every fifth course shall extend through the wall, forming a secure bond. All walls, where blocks are used, shall be laid up with Portland cement mortar.

14. Girders or Joists.—Wherever girders or joists rest upon walls so that there is a concentrated load on the block of over two tons, the blocks supporting the girder or joists must be made solid for at least 8 in. from the inside face. Where such concentrated load shall exceed 5 tons, the blocks for at least three courses below, and for a distance extending at least 18 in. each side of said girder, shall be made solid for at least 8 in. from the inside face. Wherever walls are decreased in thickness, the top course of the thicker wall shall afford a full solid bearing for the webs or walls of the course of blocks above.

15. Limit of Loading.—No wall, nor any part thereof, composed of concrete hollow blocks, shall be loaded to an excess of eight tons per superficial foot of the area of such blocks, including the weight of the wall, and no blocks shall be used in bearing walls that have an average crushing at less than 1,000 lb. per square inch of area, at the age of 28 days; no deduction to be made in figuring the area for the hollow spaces.

16. Sills and Lintels.—Concrete sills and lintels shall be reinforced by iron or steel rods in a manner satisfactory to the Bureau of Building Inspection, or the architect or engineer in charge, and any lintels spanning over 4 ft. 6 in. shall rest on block solid for at least 8 in. from the face next the opening and for at least three courses below the bottom of the lintel.

17. Hollow Space.—The hollow space in building blocks, used in bearing walls, shall not exceed the percentage given in the following table for different height walls, and in no case shall the walls or webs of the block be less in thickness than one-fourth their height, except that the Department of Buildings, architect or engineer may specially approve thinner construction after having passed the prescribed tests. The figures given in the table represent the percentage of such hollow space for different height walls.

| Stories. | 1st | 2d | 3d | 4th | 5th | 6th |
|---|---|---|---|---|---|---|
| 1 and 2 | 33 | 33 | | | | |
| 3 and 4 | 25 | 33 | 33 | 33 | | |
| 5 and 6 | 20 | 25 | 25 | 33 | 33 | 33 |

18. Application for Use.—Before any such material be used in buildings, an application for its use and for a test of the same must be filed with the Bureau of Building Inspection. In the absence of such a bureau the application shall be filed with the chief of any department having such matters in charge. A description of the material and a brief outline of its manufacture and proportions used must be embodied in the application. The name of the firm or corporation, and the responsible officers thereof, shall also be given, and changes in same thereafter promptly reported.

19. Preliminary Test.—No hollow concrete blocks shall be used in the construction of any building unless the maker of said blocks has submitted his product to the full tests required herein, and placed on file with the Bureau of Building Inspection, or other duly authorized official, a certificate, from a reliable testing laboratory, showing that representative samples have been tested and successfully passed all the requirements hereof, and giving in detail the results of the tests made.

No concrete blocks shall be used in the construction of any building until they have been inspected and approved, or, if required, until representative samples be tested and found satisfactory. The results of all tests made, whether satisfactory or not, shall be placed on file in the Bureau of Building Inspection. These records shall be open to inspection upon application, but need not necessarily be published.

20. Additional Tests.—The manufacturer and user of such hollow concrete blocks, or either of them, shall, at any and all times, have made such tests of the cements used in making such blocks, or such further tests of the completed blocks, or of each of these, at their own expense, and under the supervision of the Bureau of Building Inspection, as the chief of said Bureau shall require.

In case the result of tests made under this condition should show that the standard of these regulations is not maintained, the certificate of approval, issued to the manufacturer of said blocks, will at once be suspended or revoked.

21. Certificate of Approval.—Following the application called for in clause No. 18, and upon the satisfactory conclusion of the tests called for, a certificate of approval shall be issued to the makers of the blocks by the Bureau of Building Inspection. This certificate of approval will not remain in force for more than four months, unless there be filed with the Bureau of Building Inspection, at least once every four months following, a certificate from some reliable physical testing laboratory showing that the average of at least three specimens tested for compression, and at least three specimens tested for transverse strength, comply with the requirements herein set forth. The said samples to be selected by a Building Inspector, or by the laboratory, from blocks actually going into construction work.

22. Test Requirements. — Concrete hollow blocks must be subjected to the following tests: Transverse, compression and absorption, and may be subjected to freezing and fire tests, but the expense of conducting the freezing and fire tests will not be imposed upon the manufacturer of said blocks.

The test samples must represent the ordinary commercial product, of the regular size and shape used in construction. The samples may be tested as soon as desired by the applicant, but in no case later than 60 days after manufacture.

Transverse Test. The modulus of rupture for concrete blocks at 28 days must average 150 lb., and must not fall below 100 lb. in any case.

Compression Test. The ultimate compressive strength at 28 days must average 1000 lb. per square inch, and must not fall below 700 lb. in any case.

Absorption Test. The percentage of absorption (being weight of water absorbed, divided by the weight of the dry sample) must not average higher than 15 per cent., and must not exceed 22 per cent. in any case.

23. Condemned Block.—Any and all blocks, samples of which, on being tested, under the direction of the Bureau of Building Inspection, fail to stand at 28 days the tests required by this regulation, shall be marked condemned by the manufacturer or user and shall be destroyed.

24. Cement Brick.—Cement brick may be used as a substitute for clay brick. They shall be made of one part cement to not exceeding four parts clean sharp sand, or one part cement to not exceeding three parts clean sharp sand and three parts broken stone or gravel passing the ½-in. and refused by the ¾-in. mesh sieve. In all other respects, cement brick must conform to the requirements of the foregoing specifications.

Specifications Governing Method of Testing Concrete Hollow Block.—1. All tests required for approval shall be made in some laboratory of recognized standing, under the supervision of the engineer of the Bureau of Building Inspection, or the architect, or the engineer in charge, or all of these. The manufacturer may be present or represented during said tests, if he so desires. Approval tests are made at the expense of the applicant.

2. For the purpsoe of the tests, at least twelve samples or test pieces must be provided. Such samples must represent the ordinary commercial product and may be selected from stock by the Bureau of Building Inspection, or in the absence of such a Bureau, by the architect or engineer in charge.

In case where the material is made and used in special shapes or forms, too large for testing in the ordinary machines, smaller-size specimens shall be used as may be directed.

3. In addition to the tests required for approval, the weight per cubic foot of the material must also be obtained and recorded.

4. Tests shall be made in series of at least three, except that in the fire tests a series of two (four samples) are sufficient.

Transverse tests shall be made on full-size samples. Half samples may be used for the crushing, freezing and fire tests. The remaining samples are kept in reserve, in case duplicate or confirmatory tests be required. All samples must be marked for identification and comparison.

5. The transverse test shall be made as follows: The samples shall be placed flatwise on two rounded knife-edge bearings set parallel 7 in. apart. A load is then applied on top, midway between the supports, and transmitted through a similar rounded knife edge, until the sample is ruptured. The modulus of rupture shall then be determined by multiplying the total breaking load in pounds by 21 (three times the distance between supports in inches) and then dividing the results thus obtained by twice the product of the width in inches by the square of the depth in inches $R = 3 l W \div 2 b d^2$. No allowance should be made in figuring the modulus of rupture for the hollow spaces.

6. The compression test shall be made as follows: Samples must be cut from blocks so as to contain the full web section. The sample must be carefully measured, then bedded flatwise in plaster of paris, to secure a uniform bearing in the testing machine, and crushed. The total breaking load is then divided by the area in compression in square inches. No deduction to be made for hollow spaces; the area will be considered as the product of the width by the length.

7. The absorption test shall be made as follows: The sample is first thoroughly dried to a constant weight. The weight must be carefully recorded. It is then placed in a pan or tray of water, face downward, immersing it to a depth of not more than ½ in. It is again carefully weighed at the following periods: Thirty minutes, four hours, and 48 hours, respectively, from

the time of immersion, being replaced in the water in each case as soon as the weight is taken. Its compressive strength while still wet, is then determined at the end of the 48-hour period, in the manner specified in section 6.

8. The freezing test shall be made as follows: The sample is immersed, as described in section 7, for at least four hours, and then weighed. It is then placed in a freezing mixture or a refrigerator, or otherwise subjected to a temperature of less than 15° F. for at least 12 hours. It is then removed and placed in water, where it must remain for at least one hour, the temperature of which is at least 150° F. This operation is repeated ten times, after which the sample is again weighed while still wet from the last thawing. Its crushing strength should then be determined as called for in section 6.

9. The fire test is made as follows: Two samples are placed in a cold furnace in which the temperature is gradually raised to 1,700° F. The test piece must be subjected to this temperature for at least 30 minutes. One of the samples is then plunged in cold water (about 50° to 60° F.) and the results noted. The second sample is permitted to cool gradually in air, and the results noted.

10. The following requirements must be met to secure an acceptance of the materials: The modulus of rupture for concrete blocks at 28 days old must average 140 lb. and must not fall below 100 lb. in any case. The ultimate compressive strength at 28 days must average 1,000 lb. per square inch and must not fall below 700 lb. in any case. The percentage of absorption (being the weight of water absorbed divided by the weight of the dry sample) must not average higher than 15 per cent. and must not exceed 22 per cent. in any case. The reduction of compressive strength must not be more than 33⅓ per cent., except that when the lower figure is still above 1,000 lb. per square inch, the loss in strength may be neglected. The freezing and thawing process must not cause a loss in weight greater than 10 per cent., nor a loss in strength of more than 33⅓ per cent.; except that when the lower figure is still above 1,000 lb. per square inch, the loss in strength may be neglected. The fire test must not cause the material to disintegrate.

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The Great Pass, part of the extensive new harbor works of Alexandria, Egypt, has been completed and formally opened. The channel has a minimum depth of 35 ft. and is 600 ft. wide.

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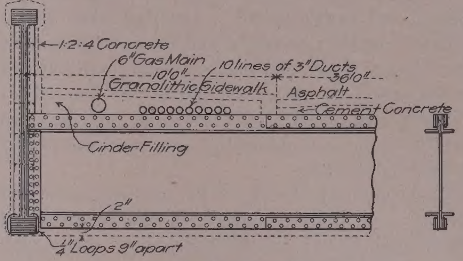
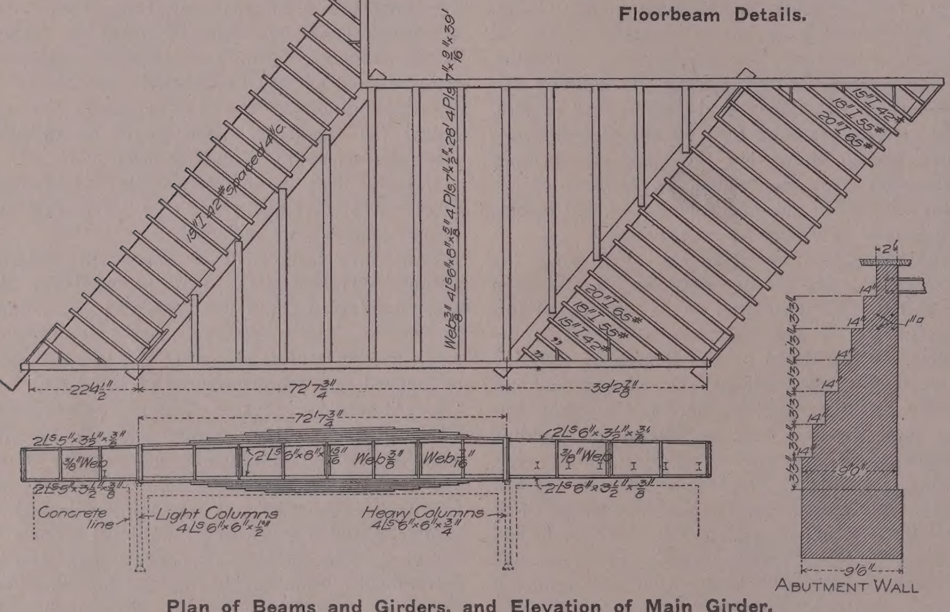
## Standard Overhead Bridge Floors, Philadelphia.

Columbia Ave., Philadelphia, is an important thoroughfare 60 ft. wide between building lines with two lines of street-car tracks. At the crossing of the Connecting Railway it is intersected at right angles by 31st St., which, however, does not cross it, but is built on one side only of the avenue, thus requiring a bridge structure, L-shaped in plan, which is carried over seven depressed tracks of the railroad, all of which make an angle of about 45 deg. with the directions of both streets. This arrangement required a very heavy skew bridge with a length of about 142 ft. on the skew and a width of about 54 ft., both in the clear.



Floorbeam Details.



Plan of Beams and Girders, and Elevation of Main Girder.

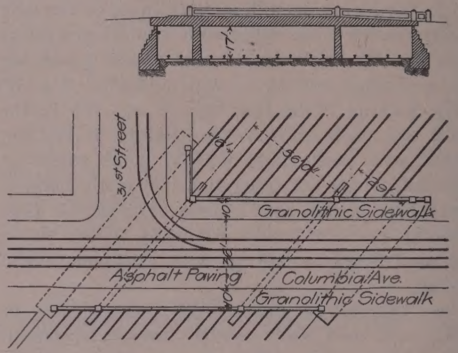
As the headway was limited and it was desired to prevent the projecting of any part of the structure except the parapet walls above the roadway level, plate girder construction was obviously suitable, but required special study to reduce the span to practical lengths, to avoid obstructing the railroad tracks beneath and to thoroughly protect all metals from the corrosive effects of the locomotive gases to which the bridge is exposed.

The difficulties of location and the awkward angle of intersection have been satisfactorily overcome by the special design of the substructure and by an original arrangement of the beams and girders, both of which have promoted simplicity and economy of construction. Aside from these considerations the superstructure is of the solid floor type, which completely protects its steelwork and has been adopted by the Bureau of Surveys as a general standard for highway bridges over railroads, and is intended to secure rigidity, freedom from vibration, great durability and exemption from maintenance expense.

The bridge has two 10-ft. sidewalks proportioned for a live load of 100 lb. per sq. foot and a 36-ft. roadway proportioned for a live load of 100 lb. per square foot or a concentrated moving load of 20 tons on each of two axles 6 ft. long and 20 ft. apart. It is designed according to the standard specifications of the Bureau of Surveys, which allow maximum working stresses of 16,000 lb. per square inch in the tension flanges of girders and 300 lb. direct compression in concrete, or 425 lb. extreme fibre stress on concrete in bending.

The substructure is of rubble concrete and consists of two piers and two abutments, all parallel with the railroad tracks, with offset concrete footings seated on rock at a depth of about 9 ft. below the railroad tracks. All beams and girders are built into the solid masonry of the substructure where supported by the latter and the piers and abutments are carried up to the roadway level. They are made with 1:3:6 concrete with embedded flat stones and have all exposed faces scored with horizontal indentations at the joints between courses to conceal the joints and relieve the blankness of the face.

The abutments both have the same cross-sections and are substantially alike except that the west abutment is about 115½ ft. long from end to end and its axis is a single straight line, while the east abutment is about 89½ ft. long with a 77½-ft. face integral with a 12-ft. oblique wing wall at one end. The piers are located in spaces 17 ft. wide between centers of tracks and are 95 ft. long with a thickness of about 3 ft. 2 in. at the surface of the ground. Because of the thinness of the piers steel columns, proportioned to carry the entire loads from the main girders, are embedded in the concrete at the ends of the piers, and between them the piers form continuous solid walls carrying the secondary beams and girders.



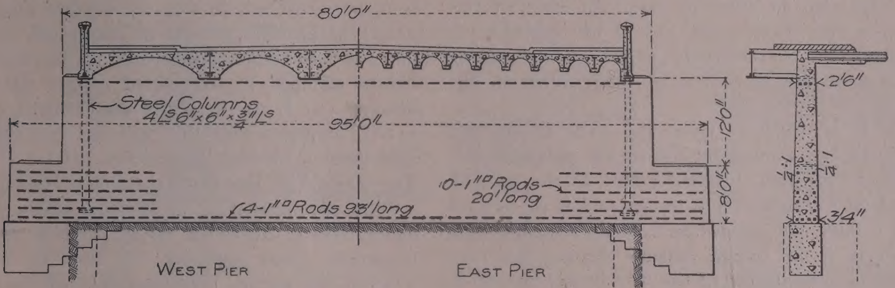
Location of Bridge.

The lower part of the pier is extended beyond each end of the main body of the pier to form a collision bulkhead 8 ft. high and about 8 ft. long, reinforced with 1-in. horizontal rods in both faces. The top of the pier is also reinforced against vertical cracking by three full-length horizontal bars just below the bottom flanges of the girders which it supports. The vertical columns have a cruciform cross-section, each made with two pairs of 6 x 6 x ½-in. angles back to back and figured to act in simple compression. They have no lateral or transverse bracing except that afforded by the solid mass of concrete which it is assumed will relieve them of all flexure and eliminate theoretical column stresses.

There are two lines of main plate girders 56 ft. apart and parallel to the center line of Columbia Ave. Each line has a 72-ft. 7¾-in. main span and a 39-ft. 2⅞-in. side span at the east end and the south line only has a 22-ft. 4½-in. side span at the west end. The depths of the main girders vary slightly in accordance with the street grades from a minimum of 90 in. to a maximum of 96 in., and they are made up with a ⅜-in. web plate and pairs of 6 x 8 x 15/16-in. full-length flange angles, each reinforced with five 14 x ⅝-in. cover plates of varying length. The side girders are 90 in. deep with 6 x 3½-in. and 5 x 3½-in. flange angles without reinforcement plates and are field-riveted to the long girders through their end web-stiffener angles.

Twelve transverse floorbeam girders 8 ft. 9½ in. apart are web-connected to the main longitudinal girders, four of which, about 56 ft. long, are connected at both ends to the main longitudinal girders. The remainder are connected at one end only to the longitudinal girders and the opposite ends are supported by the piers. The depths of these girders vary with their spans and the street grades from 3 ft. 10 in. to 4 ft. 8 in. In all of them the web plates have a uniform thickness of ⅜ in. and are not reinforced by vertical stiffener angles. The flange angles, however, vary from 6 x 3½ to 6 x 8 in. and have their flanges reversed; that is, with the horizontal legs toward the center of the girder to better accommodate and retain the encircling concrete. In the longest six girders each flange is reinforced by four vertical outside plates. In these floor girders the top flanges are proportioned only for the load of the wet concrete, the compressive stresses from paving and live load being designed to be taken up by the concrete.

The floor girders of the spans between the piers and abutments are I-beams at right angles to the piers and are 4 ft. apart and from 15 to 24 in. in depth. The intermediate I-beams are wholly supported by the substructure, but at the ends of the panels one extremity is supported by the pier or abutment and the other end is web-connected to the short longitudinal girders. In the latter case alternate beams are knee-braced to the girders with pairs of bent 3 x 3-in. angles below the floor surface.



Transverse Section of Bridge, Columbia Avenue, Philadelphia.

The bridge floor consists of concrete jack arches made with 1:2:5 concrete and having a minimum thickness of 8 in. at the crown. The arch concrete is made continuous around the lower flanges of the beams and girders to which it is locked by bent loops of ¼-in. steel 9 in. apart. Similar loops engage the concrete around the lower flanges of the main longitudinal girders, and through the webs of the latter horizontal bent bars or cramps are placed to lock in position the protecting concrete which completely encloses them and is made integral with that of the floor platform. The upper flanges of the main longitudinal girders extend about 3 ft. above the sidewalk and the concrete enclosing them is moulded to form the top of a parapet wall. The concrete in the floor arches is proportioned 1:2:5 and that enclosing the longitudinal girders 1:2:4. All of it will be machine mixed with "Dragon" brand Portland cement. In order to avoid obstructing the tracks by falsework all forms and centers will be suspended from the steelwork by vertical bolts which will be unscrewed and removed after the structure is completed.

The general features of arch and girder construction here illustrated are typical of the present practice in the Philadelphia Department of Public Works, although the details of the steelwork vary according to circumstances and in some cases lattice girders instead of plate girders have been used for these bridges. The estimated quantities in the Columbia Avenue Bridge include 140 tons of structural steel and about 2400 cu. yd. of concrete. It was designed and its erection will be supervised by the Department of Public Works, Mr. Geo. R. Stearns, director; Mr. G. S. Webster, chief engineer, and Mr. H. H. Quimby, assistant engineer in charge of design and construction of bridges. McGaw & Gray, of Philadelphia, are the general contractors and the structural steel will be fabricated by the American Bridge Co. at the Pencoyd Plant.

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## Electrolysis Surveys.

At the last annual convention of the American Gas Institute, Prof. Albert F. Ganz read a paper on electrolysis, in the course of which he gave instructions regarding the methods of conducting electrolysis surveys which apply to investigations of the condition of water mains as well as gas pipes. The paper also explained the construction and use of some appliances invented by Professor Haber, of Carlsruhe, now extensively employed in German surveys. These portions of the paper read as follows:

The first step in making an electrolysis survey of a piping system is to measure potential differences between pipes and rails in a large number of places throughout the system in order to locate these points of current flow between pipes and rails. As gas mains are not generally accessible, service or drip connections are used for making connection with the voltmeter; for this purpose one voltmeter wire is clasped or otherwise fastened to the drip or service connection, care being taken to clean with a file the part where the wire is fastened so as to insure good metallic contact. The other voltmeter wire is best soldered to a rough flat file which is held on the rail for the contact, and which can be quickly removed and replaced when a car passes. The voltmeter for these measurements should have a high resistance so that an accidental poor contact at a drip or service connection will not seriously interfere with the measurement. A suitable instrument is a portable high resistance Weston voltmeter with zero center, having ranges of 1.5, 15 and 150 volts. Readings should be taken every 10 seconds for 10 minutes at each point, and the maximum, minimum and average reading noted.

The average readings are then conveniently marked upon a map showing the principal pipes and tracks, red numbers being used where the pipes are positive to the rails and black or blue numbers where these are negative. An excellent plan is also to plot these potential differences graphically upon a map on which the pipes are shown as lines and using these lines for axes, and the voltmeter readings for ordinates; by shading the areas between the potential curves and the pipe lines with red where the pipe is positive and with black or blue where it is negative to the rails, a clear representation of the potential distribution is obtained. If the negative busbar of the power station is connected to ground plates or to other buried metal as cable sheaths, measurements of potential differences between these and the pipes should also be made and plotted upon a separate map.

The existence of potential differences between pipes and rails, even if large, is, however, no conclusive evidence of stray currents, but indicates at what points current may be flowing from rails to pipes and at what points it may be flowing from pipes to rails or to other return conductors. A high potential difference is in fact usually a sign that there is a high ground resistance and consequently but a small current flowing.

The next step is to determine the direction of the probable current flowing in the pipes. This is done by measuring potential differences between two points in a pipe by means of a millivoltmeter. A convenient instrument for these measurements is a zero center Weston millivoltmeter with two scales, one of 10 and the other of 100 millivolts. These measurements may be made between drips or service connections from 50 to 200 ft. apart. These measurements cannot be used, however, for calculating the current strength in the pipes, but only to indicate the probable existence and direction of this current. This direction of flow is then marked upon the map together with the potential readings.

In making these tests it is important that the connecting leads used with the millivoltmeter be rubber-covered wires so as to have a good insulation and to prevent the wire if coming in contact with wet ground from taking the potential of the ground and disturbing the readings. A good wire for this is No. 14 rubber-covered and double-braided wire. In one instance, while measuring the drop along a cable sheath on a wet day, getting reading of from one to two millivolts, during one of these readings the needle suddenly ran off the scale, and a voltmeter which was substituted indicated two volts. The connecting wire was found lying in water, the insulation defective, and the observers were therefore getting the potential difference between the cable sheath and the surface of the ground instead of the drop in the cable sheath.

A study of the map will show at what points determinations of current strength should be made. This is done by measuring the drop in potential between two points in the pipe by means of a millivoltmeter, and dividing this by the resistance of the included length of pipe. If this length contains one or more joints this resistance must be measured and not estimated, because joints make contacts of extremely variable resistance. As this resistance measurement is troublesome to make, it is generally more convenient to measure the drop in potential between two points in one continuous length of pipe. With very large pipes and small current this drop is a fraction of millivolt and requires a specially sensitive millivoltmeter reading to hundredths of a millivolt for its measurement. The resistance of the length of pipe can be calculated from its dimensions and from an assumed figure for the conductivity. Mr. Maury, in a paper before the American Water Works Association, has given convenient tables for converting drop in millivolts directly into amperes of current for cast-iron and for wrought-iron pipes. These tables are based upon a resistance of 0.00144 ohm per pound-foot for cast iron and of 0.000181 ohm per pound-foot for wrought iron; these figures were obtained from measurements upon a large number of pipes and agree well with those given by others and with measurements made by Professor Ganz. To find the resistance of any cast or wrought iron pipe per foot of length, it is only necessary to divide the above figures by the weight of the pipe per foot.

A matter of great importance in making these current measurements is to be sure to have perfect metallic contact between the pipe and the millivoltmeter wires. It will not do to use drip or other fittings for this connection, but contact must be made directly with the metal of the pipe. It is therefore necessary to expose the pipe where a current measurement is to be made. The presence of oxide may produce such a high resistance as to prevent a reading, and moisture can produce an electromotive force due to electrochemical action so large as to entirely offset the reading due to drop by the current. A satisfactory method is to use a pointed piece of steel about half the size of an ordinary lead pencil, with the connecting wire soldered to it, and provided with a wooden handle, the soldered joint being inside of the handle; this steel contact is pressed against a spot on the pipe which has been previously filed bright. By far the best contact is however obtained by soldering the connecting wire directly to the pipe; this is particularly advantageous when readings are to be taken over a considerable time. This soldering should be done by means of a torch and sufficient time allowed for the joint to cool to the temperature of the pipe before using it, as otherwise a thermo-electromotive force may be set up which disturbs the reading. When such contact wires have been soldered to a pipe it is convenient whenever practicable to continue these with rubber-covered wires to the surface, or to some accessible point, and to terminate the ends in small iron boxes such as drip boxes; these wires are then available for future current measurements on the pipe without going to the labor of again exposing it.

These readings of current should be taken every 10 seconds for at least 10 minutes, and the maximum, minimum and average readings noted.

By tracing the flow of currents found in the pipes from these measurements, points can be usually located at which current must be leaving the pipes, and the pipes should be exposed here and examined for evidence of electrolytic corrosion. It must be remembered that all current which is found flowing in a pipe must leave it somewhere in order to return to the negative pole of the generator. This follows from the fact that every electric circuit must be completely closed so that every ampere which leaves the positive pole of the generator must eventually return to the negative pole, no matter how long or complicated the path through which it passes may be.

There may be many other endangered points which these simple tests will not reveal. Stray currents do not always take the simple path from rail to pipe, along the pipe and back to rail or other return conductor, but frequently take roundabout paths, passing from one piping system to a second system, from this perhaps to a third system or passing across pipes, shunting around high-resistance joints, etc., producing electrolytic corrosion at every point of leaving the pipe for ground. Wherever there are two or more independent piping systems, as for instance water and gas pipes, measurements of potential difference between these should be made to see if any points can be located where current is likely to be passing from one to the other. Current measurements must then be made in the pipes at these points and plotted and studied as before.

Measurements of current should also be made at every point where a pipe crosses a trolley track or passes through particularly wet ground near trolley tracks to see whether current is passing from one to the other, as these are particularly endangered points. For this purpose it is best to expose a length of pipe on each side of the track and to measure the current on each side. It may be found, however, that this current is so fluctuating that it is difficult to draw conclusions from these readings; the passing of a car may produce an entire change in the current conditions. The best way to make the test under these circumstances is to use one millivoltmeter on the pipe on each side of the track and to take simultaneous readings of current every 10 seconds for 10 or 20 minutes. The time of taking these readings should include the passing of a car. When these readings are plotted it can be seen by comparing the current curves whether there is a change in the current in the pipe where it passes under the track, and therefore if current is passing from pipe to rail or from rail to pipe at this point. The same method may be applied in any case where it is desired to find out whether there is a change in the current flowing in a pipe between any two points in the pipe.

In making these simultaneous current measurements it is very important that the two millivoltmeters have the same period of oscillation, as otherwise, with the usual flucutating current, one would lag behind the other in its reading and the instantaneous readings would no longer be comparable. It is desirable to use two exactly similar meters and these should be strongly damped so as to move slowly enough to enable accurate readings to be taken even with a very flucutating current.

Another very important matter is the choice of time for making these measurements. The stray currents in the pipe will follow the load curves of the railway, and tests should be made at time of heaviest load as well as at time of light load. In a large railway system operating a number of stations, some of the stations may be shut down during periods of light load, and the current condition in the pipes be completely changed during these times. If the stray currents in the pipes are the combined leakage current from two or more railway systems, having different load curves, the current conditions in the pipes will also change during different times of the day, and perhaps also on different days. In cases of this kind a recording meter should be applied to a number of characteristic points in the piping system, arranged to record the current in the pipe.

It is possible to trace the path of current through the ground by measuring potential differences between different points in the ground. An iron rod driven into the ground is often used for making contact for such measurements. This however is not reliable because the electromotive force of polarisation of the iron in wet ground is dependent upon the surface condition of the iron and upon the ingredients of the ground; it is not constant, and not necessarily the same for each of two rods in different parts of the ground. Where small potential differences are measured between two points in ground by means of iron rods as electrodes entirely wrong results may be obtained because of difference in the polarisation voltages at the two electrodes.

To overcome this difficulty the "non-polarisable electrode" was devised by Professor Haber. This consists of a glass tube about 2 in. in diameter and 10 in. long, having a porous cup cemented to one end, and containing a saturated solution of zinc sulphate with a zinc rod dipping into the solution. The porous cup is pressed against the part of the ground at which the potential is to be measured, establishing contact between the ground and the zinc sulphate solution. There is only a negligible polarisation voltage between the zinc sulphate and ground. The zinc in this solution has a definite and constant polarisation voltage with reference to the solution. When two of these electrodes are used to measure the potential difference between two points in the ground, the two polarisation voltages balance each other. With these electrodes a zero method, such as a potentiometer with a sensitive galvanometer, should be used for measuring the potential differences, because the high resistance of the contact through the porous cup would produce a drop in voltage and reduce the reading on a direct reading voltmeter. This non-polarisable electrode is also used to measure the potential difference between a pipe or rail and the ground; in this case the polarisation voltage of the electrode must be taken into account, which is equal to 0.45 volt negative with reference to the iron of a pipe or rail. This means that without current flowing between pipe and ground the potential difference between an iron pipe in ground and this electrode placed nearby in the ground would be 0.45 volt, the pipe being positive. If then a measurement shows the pipe, say, 1.1 volts positive to the electrode it means that the pipe is $1.1 - 0.45 = +0.65$ volt (positive) to the ground and proves that current is flowing from the pipe to the ground. If a measurement shows a pipe, say, 0.15 volts positive to the electrode, it means that this pipe is $0.15 - 0.45 = -0.3$ volt (negative) to the ground and proves that current is flowing from the ground into the pipe. Ground potentials of less than one-tenth volt cannot safely be used as evidence of current flow as they may be due to accidental causes.

It may be desirable to measure directly the flow of current through ground as between a pipe and a rail, or between two pipes. The best arrangement for this is the "earth amperemeter" devised by Professor Haber. This consists of a wooden frame with two copper plates about 4 in. square and separated by a plate of mica or glass. These copper plates are covered with a layer of paste made of copper sulphate and water with 20 per cent. sulphuric acid, the thickness of paste being about 1/16 in. A wetted piece of parchment paper is laid over this paste and the remainder of the frame is filled with soil taken from the portion of ground where the current is to be measured. This frame is then placed in a suitable excavation in the ground where current is to be measured, so that the current flow is as nearly as possible normal to the frame, and the latter is then completely covered up, the soil being tightly stamped in. Insulated copper wires are brought out from the plates and connected with a milli-amperemeter; this will indicate the current flowing through this section of the ground. The object of the copper sulphate paste is to prevent polarisation at the surfaces of the copper plates, which otherwise would produce an electromotive force opposing the flow of current through the meter. The direction of the meter indication will give the direction of the current flow through the ground. It might be supposed that the introduction of this frame would entirely change the current conditions in the ground; this has not been found to be the case, due to the fact that the resistance of the path through the ground is very high; the displacement of the small portion of ground taken by the copper plates therefore does not greatly change the total resistance of the path of the current through the ground. The notion that the earth is a conductor of negligible resistance applies only when the path of the current is through an unlimited cross section; the resistance of a limited section of earth is comparatively high, varying under ordinary conditions from 100 to 1,000 ohms between opposite faces of a cubic foot.

This earth amperemeter is well suited for measuring current flow between pipe and ground; for this purpose the frame is buried in the ground from 1 to 2 in. from the pipe, and parallel to the pipe and normal to the probable current flow through ground. This measurement can be used to form an estimate of the probable amount of electrolytic damage to the pipe, and in cases where corrosion has taken place it will serve as evidence that it was caused by stray currents.

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A Smoke Density Meter has been devised by Mr. Edmund J. Kunze, which consists of a short piece of brass tube about 1 in. in diameter to one end of which is pivoted a revolving disc of transparent celluloid. This carries four different tints of gray, corresponding with the different densities of smoke between no smoke and jet black. In the center of each tinted section there is a small hole. When the instrument is used, the observer looks through the tube toward the smoke, turning the disc until the tint nearest the color of the smoke has been determined.

## Underpinning Buildings Adjacent to the Bridge Loop Subway, New York.

Section 2 of the Bridge Loop of the subway system of the Public Service Commission of New York City is about 2,600 ft. long on Center St. and Canal St., where it is planned to be respectively a two-track and a four-track concrete subway structure built in covered trench with subgrade at a maximum of about 50 ft. below the surface of the street. The four-track structure will be of nearly the full width of the street between building lines and as the excavation is to be carried down chiefly through sand to a considerable depth below ground water line, special precautions are necessary to avoid undermining or settlement of the foundations of adjacent buildings, many of which are old and have footings in the sand only a few feet below the surface of the street.

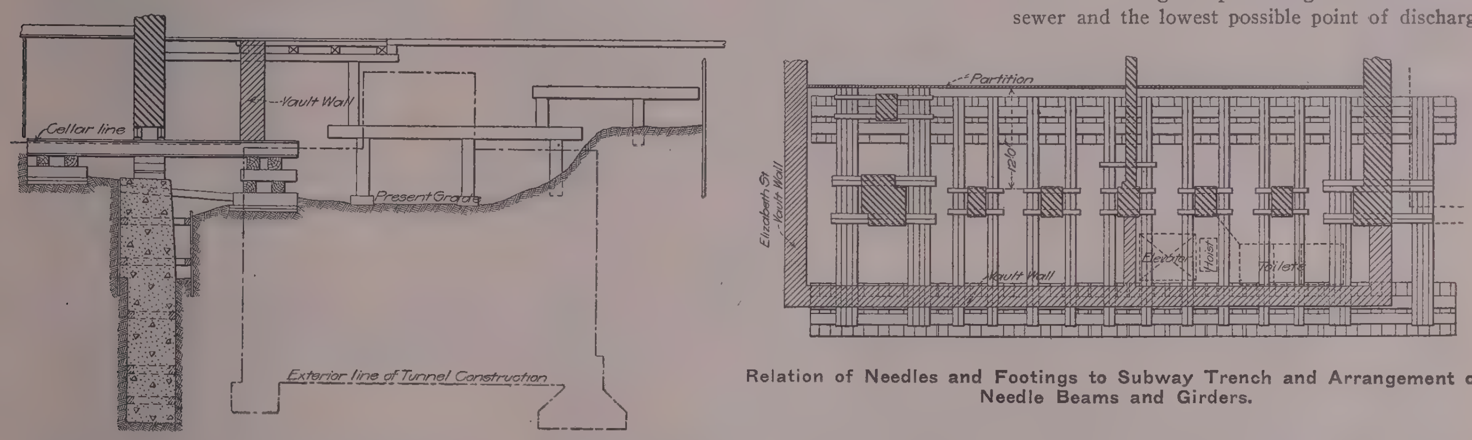
In most cases the buildings are not of extreme height or weight and both front walls and vault walls are temporarily supported on simple arrangements of needle beams where the old footings are removed and new ones built which extend to or below subgrade of the subway structure. Few of the buildings have interior columns or wall columns which require to be underpinned, but in many cases the front wall consists merely of isolated masonry piers, almost equivalent to columns, which carry comparatively large concentrated loads and require very careful and efficient support to provide against any possibility of settlement. In most cases these are cared for by a simple arrangement of secondary transverse needle beams supported on the main needle girders.

The subway excavation is generally made with ordinary pick and shovel work, carried on in successive full width lifts 6 or 8 ft. deep, under a continuous temporary plank platform on which the street traffic is maintained unobstructed. As the bottom of the excavation for the first lift is seldom much, if any, below the footings of the walls it is usually found convenient to complete the subway excavation to that point before the underpinning is commenced, since it allows all of the latter work to be accomplished without interruption under the protection of the street platform. However, if it becomes desirable to commence the underpinning before the subway excavation is thus far advanced, it is a simple matter to make the required small excavation in advance deep enough and large enough to receive the street ends of the needle girders and their supporting sills or crib work. The inner ends of the needle girders are usually supported on sills distributing their loads on the original cellar floor or are carried by sills laid on plank grillages in shallow excavations below the cellar floor.

A typical illustration of the regular methods of simple underpinning adopted for this work is afforded by E. Regenberg & Son's three-story cigar factory at No. 164-168 Canal St., at the corner of Elizabeth St. The vault wall is 55 ft. long and about 9 ft. high and will eventually be carried on the roof of the subway. The street front of the building has a brick corner pier 4½ ft .square and four 2 x 3-ft. intermediate piers. There are besides two more piers terminating transverse walls and one pier on the Elizabeth St. front, all of which were supported by the arrangement of crossed needle beams and girders shown in the general plan.

The sand is so unstable that it was considered unsafe to excavate any portion of it under the edges of the footings to allow the insertion of bearing beams for fear that the pressure would cause sand to flow into these excavations and the temporary supports were therefore placed entirely above the level of the footings, a part of the cellar floor was removed and in the shallow excavation underneath it and in a similar level space on the exterior of the wall, continuous grillages about 5 and 7 ft. wide respectively were made with cross layers of 3-in. plank and on them pairs of continuous longitudinal sills were seated on suitable 12 x 12-in. blocking. The inside sills were placed as close as possible to a temporary partition built by the contractor to protect the inner part of the cellar from disturbance and the outer sills were placed nearly in the plane of the vault wall so as to reduce as much as possible the length of the needles. Sets of two or of four 15-in. I-beams about 22 ft. long and the needle girders, one on each side of each pier were supported on the sills already placed. Horizontal slots or recesses were cut in opposite faces of the pier just above the needle girders and short 12-in. I-beams transverse to the girders were seated in them and their top flanges wedged up with wooden fillers to bearing against the masonry. Similar bearings were provided between the vault wall and the needle girder and jack screws set on the sills at both ends of the latter raised them slightly until they supported the full weight of the piers, when wedges were driven in the girder bearings on the sills, not here shown. The wedges slightly relieved the jacks and allowed the latter to be removed, leaving the wall supported through the needle beams and girders, on the two lines of grillages about 18 ft. apart with a clear space of more than 12 ft. between them.

A trench 6 ft. wide and about 12 ft. deep was excavated to water level on the center line of the wall and was sheeted with 1-in. boards driven with mauls as the excavation progressed. In the bottom of this trench a second set of sheeting 16 ft. long was similarly driven as the excavation was carried on and when it was completed to a point below subgrade it was filled with 1:3:6 concrete, deposited as the cross braces were removed. At the top of the lower set of sheeting a form wall not shown in the detail, was built and the concrete carried up to the top of it and leveled to receive pairs of wedging stones with which the connection was made with the bottom of the old pier in the usual manner. After this was accomplished the needle beams and girders were removed and the subway excavation completed, removing a little additional soil up to the face of the new wall rather than incur the extra expense of sheeting to retain the comparatively small amount of material between it and the side wall of the subway. The work was done with the approval of the Engineering Department of the Public Service Commission, Mr. Henry B. Seaman, chief engineer, Mr. Geo. S. Rice, assistant chief engineer, and Mr. Geo. H. Clark, division engineer. The details were planned and the work executed by the contractors for this section of the subway, the Degnon Contracting Co., Mr. H. C. Sanford, chief engineer, and Mr. F. D. Fisher, engineer in charge



Relation of Needles and Footings to Subway Trench and Arrangement of Needle Beams and Girders.

## Sewage Disposal at Tuckahoe, N. Y.

A sewage disposal plant, consisting of two 2x4½x14-ft. detrius tanks, five 9x11½x42-ft. septic tanks, and two 100x100-ft. aeration beds, has been constructed to purify the sewage of Tuckahoe, N. Y., a suburb of New York City, with a population of about 2,000. The plant is designed to deliver into the Bronx River a non-putrescible effluent and contains some interesting features necessitated by the slight difference in elevation between the highest possible grade of the main sewer and the lowest possible point of discharge into the river. The difference in level between the invert of the sewer at its entrance to the detritus tanks and the invert of the effluent carriers as it leaves the aeration beds is only 3 ft. 3 in. The outfall sewer discharges into a penstock 9 ft. 6 in. long, 2 ft. 9 in. wide and 4 ft. deep, with gates leading into the two detritus tanks. The depth of sewage in these is ordinarily about 4½ ft. There is a storm water overflow from the penstock so that flood water need not go through the plant. The outlets from the detritus tanks into the septic tanks are through a semi-circular chamber with radial carriers leading to the points of inlet. The depth of sewage in the septic tanks is 7 ft. 6 in., giving each tank a capacity of 50,000 gal.; each tank is designed to handle about 30,000 gal. per 24 hours. The beds are fed by a main carrier 3 ft. wide running alongside both beds. The bed of the carrier is level. Parallel with the main carrier is the distributing carrier, also with level channel, and connected with the main carrier by seven openings, each provided with a gate. In the wall of the distributing carrier are 18 openings to equalize the distribution of sewage. The beds have concrete floors and walls, and are filled to a depth of 6 in. with 2½-in broken stone, and are inclined 6 in. towards the side opposite the main and distributing carrier, where there is an effluent carrier leading into the river. In order still further to facilitate the distribution of sewage, three single rows of brick are set on the floor across the beds, the brick being on edge with slight intervals between them. The effluent carrier has a fall of 1 ft. in its length of 200 ft., insuring quick discharge of the purified effluent. The aeration beds are of sufficient capacity to transform the effluent from all five resolving tanks, a total of 150,000 gal. a day, into a nonputrescible effluent to pass the test of the New York State Board of Health. Connections for a population of about 600 only have been put in, according to the "Municipal Journal and Engineer," from which these notes have been taken. Mr. George H. Rogers, village engineer, designed the plant, which cost about $12,500.

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## The Wagaraw Bridge at Paterson.

The Wagaraw Bridge, built during the past year over the Passaic River near Paterson, N. J., is a three-span reinforced concrete structure 320 ft. long face to face of abutments. It replaces an old double-intersection, pony, Howe, timber truss, part of which is shown in an accompanying illustration. The new structure is designed to carry a uniform load of 150 lb. per square foot on the whole bridge or any part, and also two 24-ton electric cars on any part of the structure. The center span is 108 ft. long in the clear, with a rise of 12 ft., and each end span is 96 ft. long in the clear, with a rise of 9 ft. 6 in. The width of the bridge is 40 ft. over all, comprising a 26-ft. roadway and two sidewalks each 7 ft. wide including the handrails and posts. The spans are all three-centered.

The spans vary so little in length that the dimensions of the three arches are very nearly alike. They are all made up of a tapering arch slab without ribbing, carrying two outside spandrel walls, between which is retained a well rammed earth fill. The center span arch is 2 ft. 4 in. thick at the crown and about 7½ ft. thick at the springing line. At the point of compound curvature on the intrados just above the haunch, the thickness is 3 ft. 8 in. The spandrel walls at the haunches are 2 ft. 3 in. and 3 ft. 6 in. thick at the top and bottom, respectively, as shown in an accompanying cross-section. The form and important dimensions of the piers and abutments is shown on the drawings.

The steel reinforcement in each arch consists of a double series of Kahn cup bars near the intrados and a similar series near the extrados. The longitudinal bars of each series in each arch are 1-in. size and are placed 2 ft. on centers. The transverse bars are ¾-in. size spaced 3 ft. apart. The piers and abutments are not reinforced.

The contract for the new structure included the demolition and removal of the old bridge, and the contractors found it very advantageous to wreck the wooden trusses only as fast as the new work progressed. It was determined to use the chord members of the old bridge for falsework stringers to support the lagging for the new bridge and before work was begun detailed plans of the falsework were prepared with this in view. The curve of the intrados was formed on the stringers by special pieces cut to shape in a planing mill and spiked in position. The trestle bents were spaced to fit the lengths of the old timbers and much cutting that would otherwise have been necessary was thus avoided.

The trestle bents were framed on the west bank of the stream just below the bridge and were towed out to place and erected under the old wooden trusses, the old bridge being still in place on its piers and affording a secure working platform. The bed of the stream is hard and good footings for the trestle posts were readily secured. When the bents were in place, the old bridge was taken down. The trestle bents, in turn, facilitated this part of the work, as they were used to a certain extent as scaffolds by the workmen. The stringers, with their curved pieces attached, were put in place on the bents as fast as the old bridge was removed. The caps of all the bents were necessarily below the level of the lower chords of the old timber trusses and the stringers were supported on wedges bearing on the caps. These wedges were varied in number and adjustment to bring the lagging to the proper elevation. The elevations at each bent had been calculated and the stringers were readily adjusted by level readings.

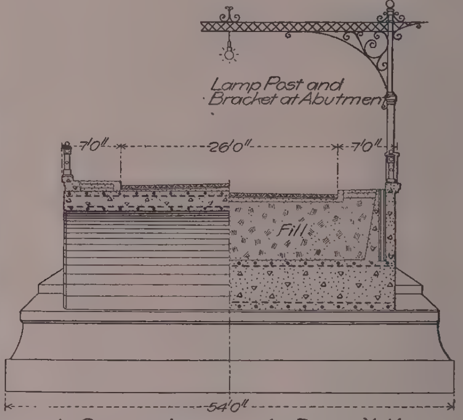
The concrete in the piers, abutments and arches is a 1:3:5 mixture of Atlas Portland cement, sand and crushed trap rock about 1½-in. in size. It was mixed in a Chicago cube mixer made by the Municipal Engineering & Contracting Co. It was fitted with a charging elevator and proved very efficient. Sterling two-wheel hand carts were used to deliver the concrete to place. The piers and abutments were built separately, and the arches between them were constructed later. An expansion joint was thus formed at the end of each arch where the arch concrete butted against the older concrete of a pier or abutment. Each joint was made up of two intersecting planes, one vertical and the other inclined at an angle of 45 deg., the latter extending inward from the springing line.

The concrete in each arch was placed in seven parallel strips, each a little less than 6 ft. wide. On each span the first strip was always laid along the upstream side to load the falsework and hold it securely in place. The next strip was laid along the downstream side and then the strips were successively alternated from one side to the other, the seventh and last strip coming over the center line of the bridge. The laying of concrete on each arch was divided up into seven sections rather than any other number because each rib or strip then contained about 60 cu. yd., and it was thought that this quantity of concrete could be laid in a day by working at a good speed. This was successfully accomplished and little time was lost through lack of work to keep the gangs busy. The forms were carefully made of 2-in. dressed lumber, and were oiled with a special oil prepared for this purpose; soap was used on the forms in the earlier stages of the work, but this was found unsatisfactory.

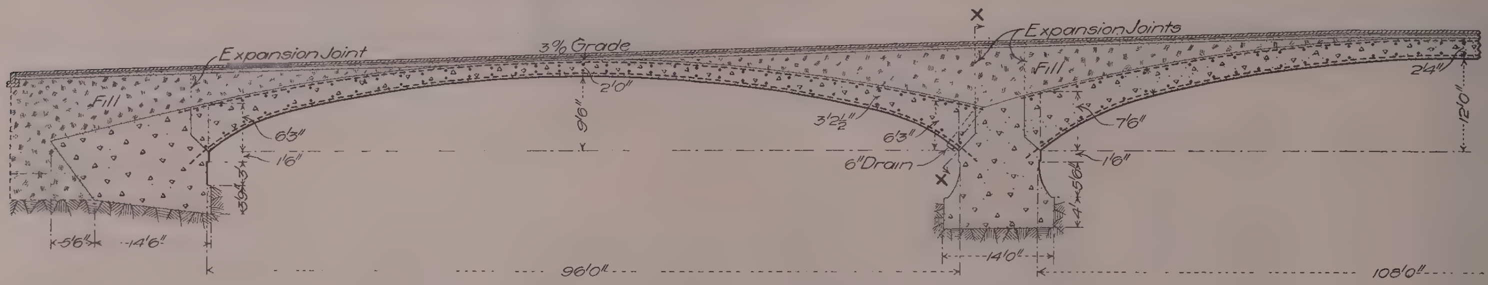
The structure contains about 3,700 cu. yd. of concrete, and the contract price for it was $37,200. Work was begun Aug. 1, 1907, and the last rib of the last arch was laid Nov. 12. The centers under the first arches were struck about 10 days later; the maximum deflection noted at this time was 2¼ in. The average force employed was about 40 men. After the earth fill was in place it was deemed inadvisable to lay the pavement and sidewalks on account of approaching cold weather, and accordingly temporary railings were erected and the bridge was opened to traffic without the pavement. The small amount of work that remains to be done will be finished next spring.

The bridge was designed by Messrs. Colin R. Wise, county engineer of Passaic County, and F. W. Schwiers, Jr., of New York, who was retained as engineer by Bergen County. Later Mr. Ralph D. Earle, Jr., was made county engineer of Bergen County and the construction work was executed under the joint supervision of Messrs. Wise and Earle, county engineers. The Schwiers & Sutton Co., New York, was the contractor.

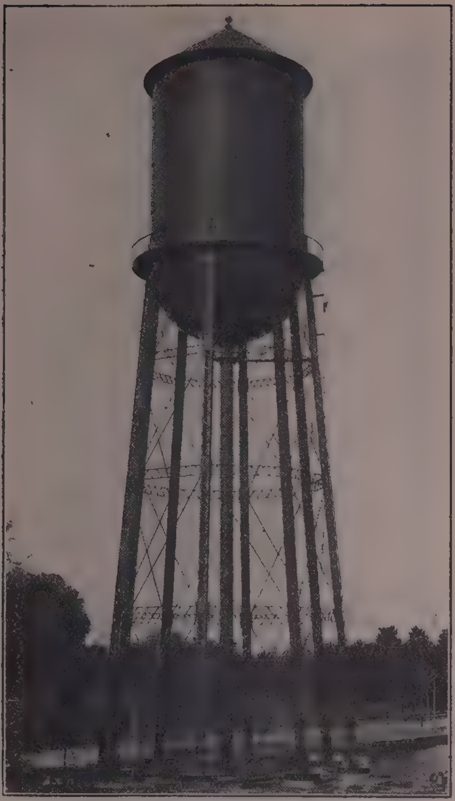
Center Span of Wagaraw Bridge and Part of Wooden Trusses.



Sections of Bridge.



Part Section of Wagaraw Bridge Over Passaic River, near Paterson, N. J.



Large Water Tower at Louisville, Ky.

## A Very Large Water Tower.

The recent improvements in the water supply system of Louisville, Ky., include a high-pressure service with a very high steel tank. The Louisville Water Co. invited bids for a steel stand-pipe 50 ft. in diameter and 220 ft. high, but as the water in the lower part of such a structure would not be available for the required service it was decided that economy of design and convenience of construction would be promoted by replacing the stand-pipe by a tank supported on a tall steel tower, and thus eliminating the excessive hydrostatic pressure in the lower part of the structure. This was accordingly done, and the structure has been built as indicated in the accompanying illustrations.

The tank has a capacity of 1,200,000 gal. of water, equal to a 10,000,000-lb. load. It is a riveted steel cylinder 50 ft. in diameter and 65 ft. 4 in. in height with a hemispherical bottom and a conical roof, and is supported on eight battered riveted steel columns 155 ft. high. A vertical riveted steel pipe 50 in. in diameter is connected to the center of the bottom and to horizontal mains about 12 ft. below the surface of the ground and serves both for inlet and outlet. The lower part of the tank is surrounded by an annular steel balcony platform and hand rail, accessible from the ground by steel ladders carried up on one of the tower columns. Another vertical steel ladder extends from the bottom to the top of the tank outside, and affords access through a steel door in the roof to a corresponding inside ladder. The projecting lower edge of the roof forms a sort of cornice around the top of the tank and an opening through the upper part serves as a ventilator and is surrounded by a spherical finial and a flag-post extending nearly 40 ft. above it. The columns have separate masonry foundation piers carried down to hard strata and finished on top with short steel cylinders 10 ft. in diameter enclosing the concrete which surrounds the I-beam grillages, which distribute the column loads over the masonry.

The columns are proportioned for a maximum static load from combined dead weight and weight of water of about 1,480,000 lb. each, which, added to the maximum wind pressure stresses serves a total of 1,765,000 lb., provided for by a gross cross section of 106.4 sq. in. in the lower sections. They are built in four stories, and are connected at each story by horizontal struts, each set of which makes an octagon. The panels between the columns and struts in the outer faces of the tower are X-braced with double pairs of sleeve nut rods, 32 in each story, varying from 1½ in. square at the top to 1⅞ in. square at the bottom. The struts are all light latticed girders with pairs of angles back to back for the flanges and single zig-zag angles for the web members. Their depths over all are 30 in., 36 in., and 42 in. for the upper, intermediate and lower sets, respectively. Short web plates on both ends are riveted between the flange angles and extend beyond them vertically to receive the pin connections for the diagonal rods. They also extend beyond the ends of the struts and are bent to provide field riveted connections with the webs of the tower columns.

The columns have rectangular cross section made throughout with a pair of 24-in. built channels with a 34-in. cover plate on one flange and the other flange latticed with zig-zag 3½ in. angles. The inside flanges of the columns are made with 8 x 8-in., and the outside flanges with 6 x 4-in. angles. The ends of the columns are faced square and are spliced, just above the horizontal struts with four single web and flange cover plates. The feet of the lower sections of the columns are faced and are riveted to horizontal ½-in. base plates, which extend beyond the faces of the columns and are bent upwards to the angle of the diagonal rod to which they are pin-connected. The base plates are stiffened by the flange connection angles and by short vertical reinforcement angles riveted to the column webs. A pair of short, vertical transverse diaphragms inside the foot of the column are riveted to the web plates and are faced to receive at the upper end a bearing plate 1 in. thick engaging the nut on the upper end of a 3½-in. vertical anchor rod.

Drilling Holes in Hemispherical Bottom at Shop.

The upper sections of the columns are about 41½ ft. long over all, and are made regular at their lower ends. About 20 ft. above the bottom splice the inner flange angles are bent vertical with their outstanding flanges in the plane of the cylindrical face of the tank. The outer flange angles are similarly bent about 11 ft. higher up, and above this bend the inner and outer angles are parallel and about 13 in. apart. The column flange cover plate, which is on the inside of the column, terminates about 2 ft. below the cylindrical part of the tank, just clearing the hemispherical bottom and to it and the webs are riveted a pair of 8 x 8 x ¾-in. angles 20 ft. long parallel to the main flange angles and with them receiving the field rivets connecting the columns to the cylindrical part of the tank; 312 1-in. rivets at each column, making a total of 2,496. In the tapered part of the column adjacent to its connection with the tank, the channel webs are reinforced by fillers and outside cover plates and vertical gusset plates are riveted to them, forming brackets supporting the balcony platform. This platform, 5½ ft. wide, is made with full width floor plates ¼ in. thick, stiffened at the inner edge with a 3½ x 3½ x ⅜-in. curved flange angle field riveted to the tank. Similar flange angles stiffen the outer edge and two intermediate radial vertical gusset plates between each pair of columns divide it into sections about 6½ ft. long. The hand rail, 5 ft. high, is made of a single 3½-in. flange angle and multiple intersection 1½ x ¼-in. diagonal strips.

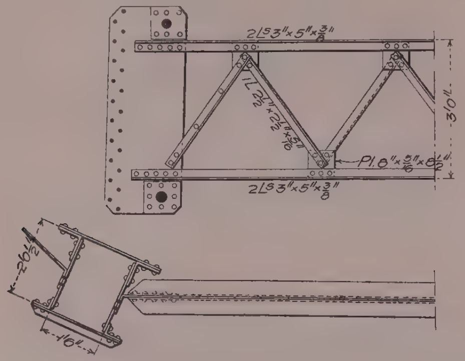
The tank has eight horizontal courses of curved vertical plates from 96 in. high at the bottom to 102 in. high at the top, with eight plates in each course. The horizontal joints between courses are telescopic, alternate courses being inside and outside. The horizontal lap joints are all made with a single row of rivets and the vertical joints in the upper four courses are made with a lap with two to four vertical rows of rivets. In the lower courses the plates make vertical butt joints spliced with inside and outside cover plates having six vertical rows of rivets. The thickness of the course plates varies from 5/16-in. at the top to 1 in. at the bottom, where the lower edge is reinforced by 13 x ½-in. inside and outside cover splice plates field riveted to it and to the ¾-in.

curved hemispherical bottom plate, as indicated in the detail.

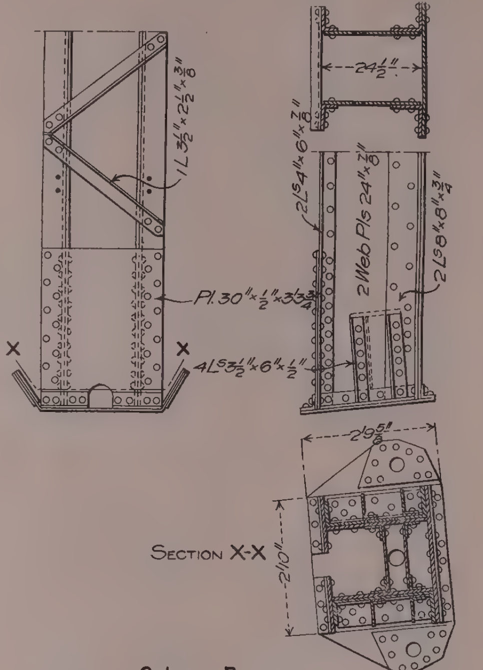
The hemispherical bottom is made with two courses of ¾-in. plates, having 24 and 12 pieces in each. Each plate requires two 16½ x ½-in. butt straps with six rows of ⅞-in. rivets, 11,480 in all. There is also a bottom plate 10 ft. 9 in. in diameter with a flange connection for the vertical inlet and outlet pipe.

The conical roof has a diameter of 56 ft. at the base and a rise of 21 ft. to the vertex, and is made with three courses of overlapping ¼-in. plates secured with ½-in. rivets. In the top course there are four plates curved to an 8-ft. radius, in the second course 16 plates, 13½ ft. long, and in the lower courses 32 plates, 14 ft. long. A circular opening about 28 in. in diameter at the top of the roof is reinforced by an inside circumferential angle with holes through the outstanding flange to receive 16 ⅝-in. screw rods, forming the lower chords of light triangular trusses to support the roof. The lower ends of these rods are connected to the feet of angle struts normal to the roof and riveted at their upper ends to a horizontal flange angle at the joint between the second and third courses of roof plates. The feet of the inclined struts are connected by a horizontal circular angle about 26 ft. in diameter, which receives 96 screw end ⅝-in. horizontal radial rods with their outer extremities passing through the upper edge of the cylindrical walls and 48 similar rods with their inner ends bolted between a pair of horizontal 3⁄16-in. spider plates 44½ in. in diameter, which receive the foot of the flag-pole.

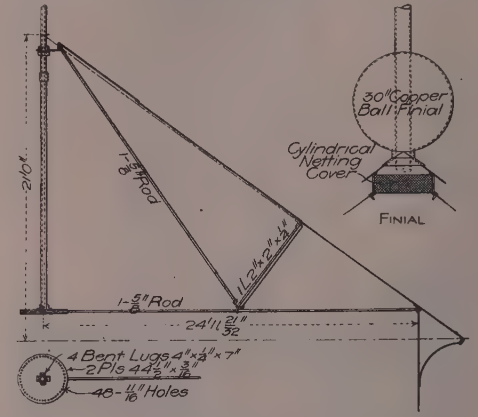
The flag-pole, 68 ft. long over all, is made with three telescopic sections of gas pipe, 3, 3½ and 4-in. in diameter, and is secured at the peak of the roof by horizontal bent plates bolted to it and riveted to the connection ring at that point. The hole in the top of the roof is covered by a conical cap plate 7 in. vertically above it with the space between enclosed by a cylindrical copper netting to allow for ventilation and exclude birds, insects, etc. The lower edges of the roof project 34 in. beyond the walls of the cylindrical tank and are connected to them by 96 curved cornice plates.



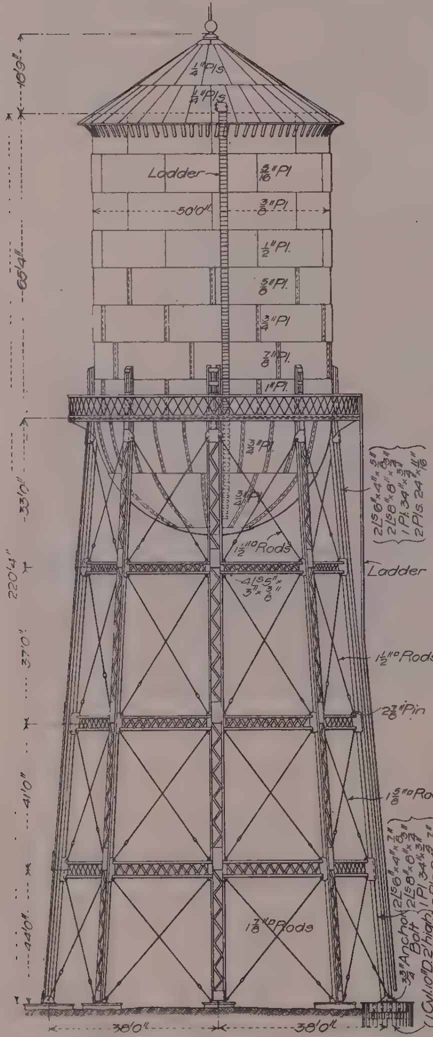
Horizontal Strut.



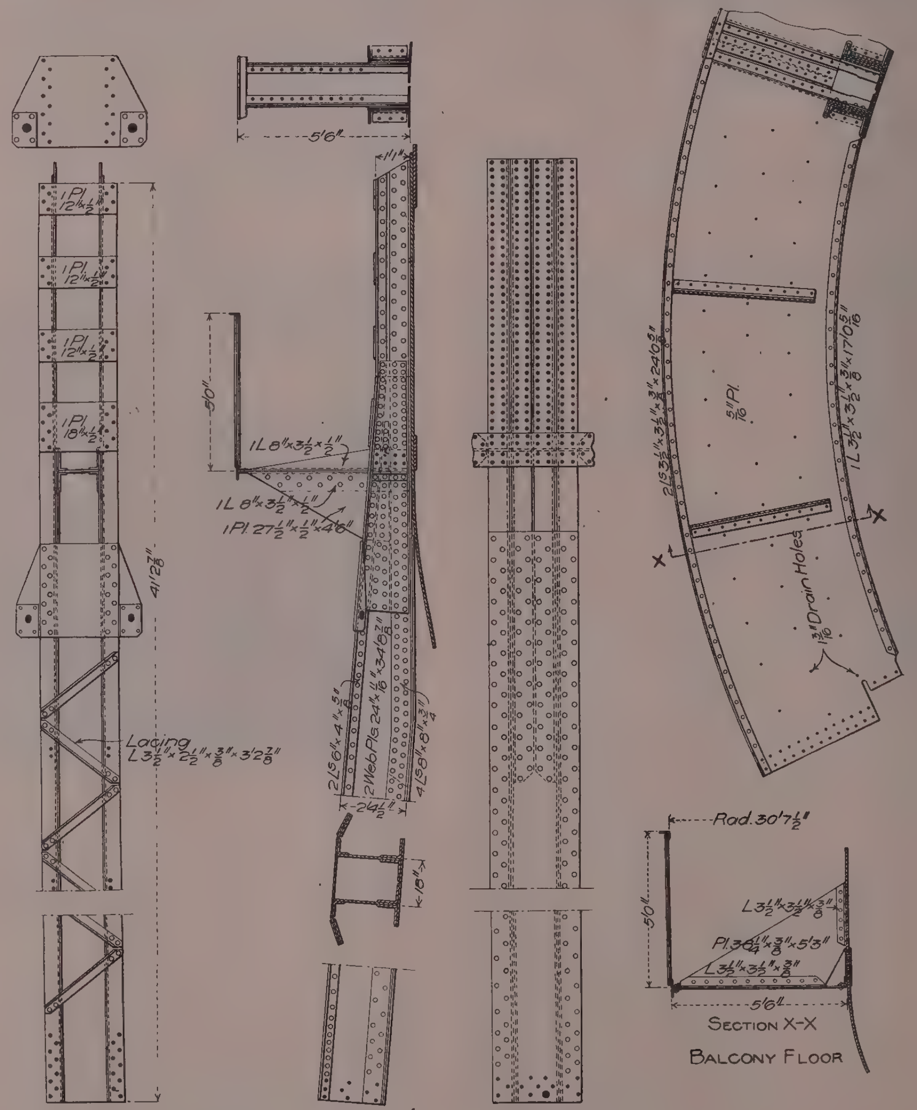
Column Base.



Roof Truss and Finial.



Tower and Tank.



Upper Section of Column, Tank Connection and Balcony Floor.

The plates for the first course of the cylindrical portion of the tank and those for its hemispherical bottom were completely assembled at the bridge shop yard in reverse position, making a dome 50 ft. in diameter and nearly 60 ft. in height. The erection was accomplished by means of a wooden spar nearly 80 ft. long, secured at the foot on the ground at the center of the dome and at the pipe connection hole, where it passed through the top of the dome. The spar was equipped with four light booms like those used on sail boats, which sufficed for handling the separate plates of a maximum weight of 6,500 lb. each, as well as four reaming machines suspended from them with tackles. Two of the machines were of special design made by the Chicago Bridge & Iron Works, and operated by electricity. The other two were Chicago pneumatic reamers, and all of them were provided with light frames maintaining the drills always in a position radial to the hemispherical plates. With these machines 15,000 holes were accurately reamed, each through about 2 in. of metal. Twist drills were used for the reaming and outside scaffolds were supported on brackets bolted to the plates to afford platforms for the workmen. Neither the tower nor the upper part of the cylindrical tank was assembled at the shop.

The material for the water tower was raised into place with a 14 x 14 x 56-ft. gin pole with four guy lines, the pole being moved about adjacent to the position of the eight posts, the anchor bolts holding the lower sections of the posts in position until connections were made with horizontal struts and diagonal brace rods. When the first story of the tower was completed, the gin pole was elevated onto the struts and the process repeated for each of the eight posts for this and the two upper stories. Next the horizontal girder was placed in position, then the lower ring of the cylindrical part of the tank. From these two was suspended the hemispherical bottom. A much lighter gin pole was used in placing these parts, as the largest plates only weighed about 8,000 lb., while the main posts weighed over 25,000 lb. each.

The horizontal girder, the lower ring of the cylindrical part and the hemispherical bottom were all completely fitted up, pinned and bolted before any rivets were driven. The upper part of the tank was identical with the usual practice of stand-pipe erection. The rivets were driven by pneumatic power.

After the hemispherical bottom of the tank was erected a temporary platform was built on it and a stiff leg derrick placed there by which the cylindical tank and roof were erected. The total weight of the structure is about 650 tons, which is about equally distributed between tower and tank, and it was erected by an average force of about 12 men in about 300 days.

The tower was built for the Louisville Water Co. under the direction of the late Charles Hermany, engineer, by the Chicago Bridge & Iron Works, Mr. Horace E. Horton, proprietor, and Mr. Geo. T. Horton, engineer and manager.

Analysis of comparitive designs for a water tower and a stand-pipe for storing 1,200,000 gal. of water at a minimum height of 155 ft. showed that a stand-pipe would cost more than three times as much as the elevated tank and tower for this service. For an average elevation of 50 ft. or less the cost of stand-pipe and elevated tank are about equal. For an average elevation of 100 ft. the stand-pipe costs twice as much as the elevated tank. For an average elevation of 150 ft. the stand-pipe costs three times as much as the elevated tank and so on, being four times as much for 200 ft., five times as much for 250 ft., and six times as much for 300 ft. Of course, for extreme heights the maximum hydraulic pressure would produce tremendous stresses at the foot of the stand-pipe, making its construction very difficult and costly. It was computed that a stand-pipe 50 ft. in diameter and 220 ft. high would require metal 2 4/10 in. thick at the base, thus necessitating two thicknesses of plates.

Wood Blocks laid alongside rails are preferred on asphalt-paved streets in Frankfort, Germany, to any other system of connecting the street tracks and the paving. The blocks are laid over the whole space between the rails and for some distance outside the rails.

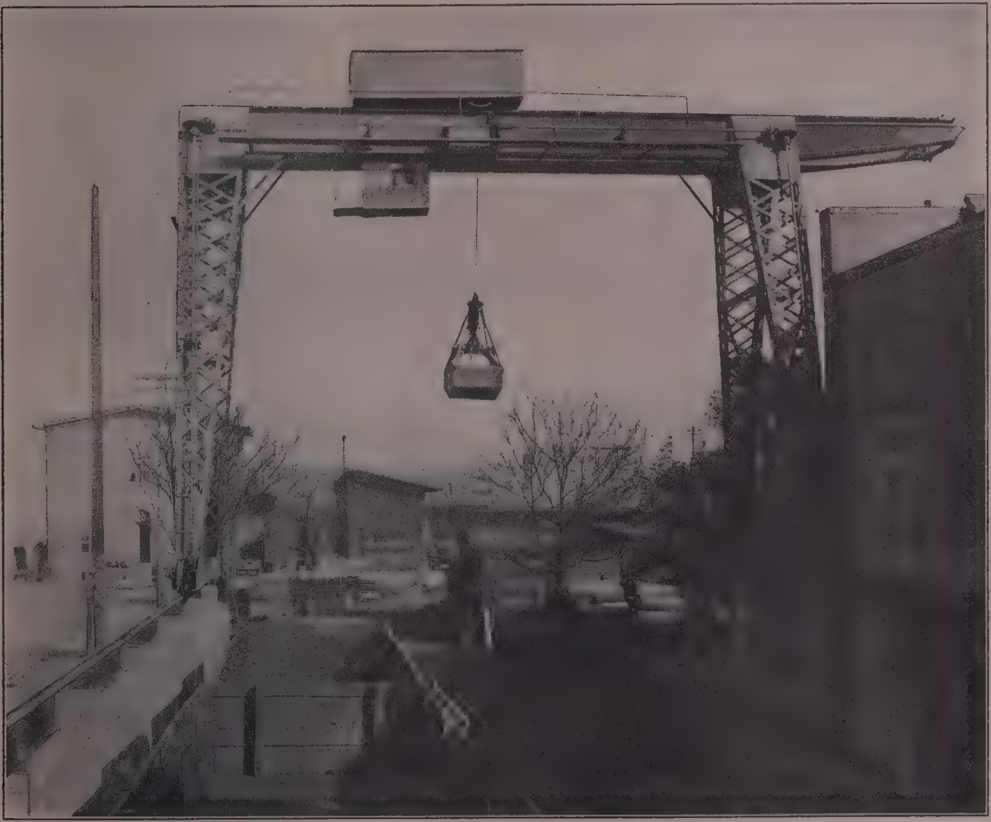
## Coal Handling at the Dayton Citizens' Electric Station.

The Dayton Citizens' Electric Co., of Dayton, O., has recently completed a central station for supplying light, heat and power to the business and residence sections of the city, a district steam-heating system being operated during the winter season by distributing the exhaust steam for this purpose over an area having a radius of about 1½ miles from the plant. The building is 60 x 128 ft., of reinforced concrete with brick veneering on the front. A basement is provided for the condensing apparatus, for use during the summer when there is no heating service.

In the design of the station provision was made for the installing of eight 500-h.-p. Stirling boilers, although the actual number in use at the present time is four, which supply the steam for two 1000-kw. Westinghouse-Parsons steam turbines. The breeching for these boilers is carried downward to a flue duct which runs lengthwise of the building, with its top level with the floor of the engine room; thence the gases are conducted to the reinforced concrete chimney of 12 ft. inside diameter and 180 ft. height. This chimney is of ample capacity to provide for an equipment four times the size of the present installation. The arrangement of the plant, the design of the building and its erection were under the charge of Mr. John Bronton. The contractors for the building and the underground work were the Abbott-Gamble Co., of New York. The American District Steam Co. furnished the equipment for the steam-heating system.

In an effort to get away from the multiplicity of detail incident to the installation of a pivoted bucket system, a coal-handling gantry crane with grab-bucket was designed and built by the Cleveland Crane & Car Co., Wickliffe, Ohio. The runway for the gantry crane was raised about 8 ft from the ground, which allowed a storage capacity of about 2,000 tons of coal in addition to the 200 tons in the bunkers. By means of the gantry crane and grab-bucket, coal can be unloaded directly from the cars into the bunkers, or can be taken from the car and deposited in the storage yard, to be rehandled at a future date when it becomes necessary to convey it to the bunkers.

The entire operation is conducted by one man. By traveling with the load, the operator can fill the bucket and discharge the load without extra help. The advantages claimed for this system are low cost and ease of handling material, low cost of installation and maintenance due to size and small number of working parts, and large area served.



Coal-Handling Gantry Crane, Dayton Citizens' Electric Station.

Compressed Air now forms quite a feature in laundry work, and the Westinghouse Air Brake Co. has lately devoted considerable attention to the application of its standard compressors to such service. In a recent installation a 9½ x 11 x 10-in. compressor was mounted on the wall of the building so as not to take up floor space. It is supplied with steam at 100 lb. and the exhaust is used for heating the building and the feed water. The air inlet is piped through the top of a neighboring window. The compressed air is discharged into two reservoirs connected together. Both high and low-pressure pipes are taken from the second of these reservoirs, one of the company's standard feed valves being used to control the low-pressure line. Very low pressure is required for gas burners, sprays and rolls, while a higher pressure is necessary for the dampening presses. By a proper adjustment of the air and gas supplies it is found practicable to reduce the amount of gas to a minimum while improving the character of the service. In one plant the gas bills were reduced 20 per cent. after installing a compressed air plant, although the increase in business was about 20 per cent.

## Economical Design of Reinforced Concrete Beams.

By Elie Cannes, C. E.

Many formulas have been advanced for the design of reinforced concrete beams, and although a definite, scientific one has yet to be found, experiments and experience in all kinds of construction work are sufficient proofs of the safety and efficiency of these formulas. The strength and resistance are the principal considerations to have in mind in determining the proper dimensions of a reinforced concrete beam, but the cost of the same is not less worthy of attracting the attention of the engineer.

In the case of a steel beam, its manufacturing cost is outside of the province of the engineer. He has nothing to do with its making, which is done in the most cases hundreds of miles from the place where it will be utilized. Not so in the case of a reinforced concrete beam. The amounts of steel and concrete are determined by the engineer and the beam made on the work. The price of each element differs in the various parts of the country, being dependent upon the distance of manufacturing centers, and upon the abundance or scarcity in the locality of stone, gravel, sand and water.

The cost of a reinforced concrete beam will then depend on the relative combination of both materials, i. e., upon the percentage of steel.

Although the importance of the economical question in the design of a reinforced concrete beam would seem to be self evident, the question has been neglected by authors of works on reinforced concrete. The writer having had for the last few years to make large use of reinforced concrete, particularly in tunnel work for a large New York company, has been obliged to study this question for himself and to find what percentage of reinforcement will give the least expensive reinforced concrete beam under conditions of cost of concrete and steel in New York City.

The results of his investigations are shown in the accompanying diagrams, which also contain diagrams based on conditions of cost of steel and concrete in other parts of the country. All the diagrams have been figured and plotted on the following assumptions: (*a*) The allowable unit compressive stress in concrete, 500 lb. per square inch; no tension in the concrete. (*b*) The allowable unit tensile stress in the steel, 20,000 lb. per square inch. (*c*) The distribution of the compressive stresses in concrete is parabolic with apex in the neutral axis. (*d*) The width of the beam is one foot; only the effective depth of the beam is considered. (*e*) The ratio of cost ($r$) of a cubic foot of steel to that of a cubic foot of concrete has three values, namely, $r = 30$, $r = 40$ and $r = 60$.

The ratio $r = 40$ is the one which is applicable to the conditions of cost of steel and concrete in New York City.

The diagrams have been figured by assuming an arbitrary moment and finding the corresponding depth of the beam for each percentage of steel. The width being constant the area and volume per foot of length are known, and the cost can be figured. The curve for stress in concrete was obtained by holding the steel stress constant at 20,000 lb. per square inch, while the curve for stress in steel was obtained by holding the concrete stress constant at 500 lb. per square inch, and varying the percentage of reinforcement.

The point of intersection of the corresponding curves for the fixed stress in the concrete and the fixed stress in the steel represent the cost of a beam in which the working stresses in steel and concrete are the maximum allowable stresses. The percentage giving these stresses is the safe minimum percentage of reinforcement. It is 0.35 for $n = 10$ and 0.45 for $n = 15$, $n$ being the ratio of the moduli of elasticity of steel and concrete.

If in the design of a reinforced concrete beam we would follow the same method as in an ordinary steel beam without any regard to its cost, this percentage would be the one to use in all cases, as it satisfies the conditions of stresses. But it does not give the least cost of the beam.

The curves of fixed steel stress in Fig. 1 and Fig. 2 would seem to give the minimum cost, but the stresses in concrete in this case increase to such an extent as to decrease sensibly the factor of safety. For instance, with a percentage of 0.6 for $n = 10$, the stress in concrete will be about 700 lb. per square inch.

In designing the beam with fixed concrete stress, however, the steel stress in the beam with a percentage giving the minimum cost, decreases and is less than the allowable working stress. The table below gives the percentage for minimum cost, which is the economical percentage and the corresponding stress in steel for different ratios $r$.

| | $n = 10$ | | | $n = 15$ | | |
|---|---|---|---|---|---|---|
| $r$ .............. | 60 | 40 | 30 | 60 | 40 | 30 |
| Economical percentage .. | 0.40 | 0.60 | 0.80 | 0.40 | 0.60 | 0.70 |
| Steel stress, lb. per sq. in. | 18,300 | 14,400 | 12,100 | 21,600 | 17,100 | 15,300 |

From the inspection of the curves it will be noticed that the minimum cost and the economical percentage of steel shift to the left, as the ratio $r$ increases, and that for $r = 60$ in Fig. 2 the economical percentage is even smaller (0.40) than the safe minimum percentage, which is 0.45. The former will still be smaller when $r$ is more than 80 for $n = 10$, in Fig. 1. It shows that in this case the economical percentage will give the cheapest, but not the safest beam. It has therefore to be abandoned and the safe minimum percentage used instead, which will be the economical percentage as well. It follows, therefore, that for any ratio $r$ more than 60 in Fig. 1 and 40 in Fig. 2 the percentage of steel which will give the most economical design of a reinforced concrete beam, will be the safe minimum percentage, while for any other ratio less than these figures the economical percentage will be that given in the above table.

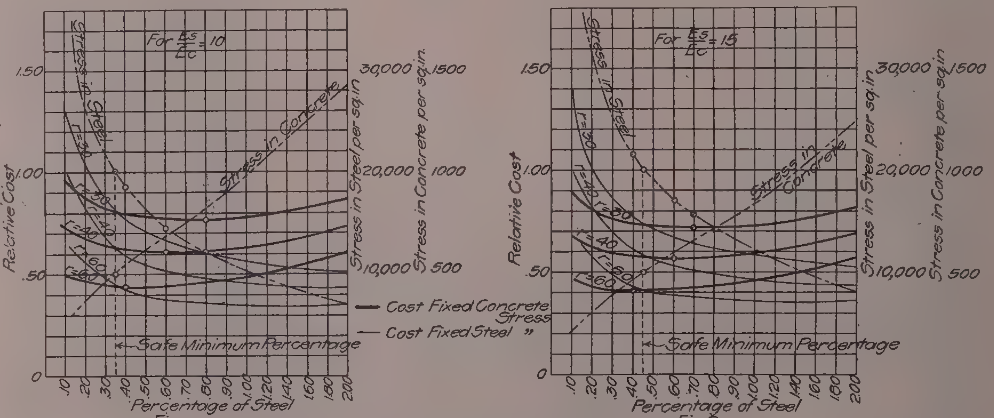


Fig. 1 Fig. 2

Cost Diagrams of Reinforced Concrete Beams.

The tensile stress in steel for the economical percentage varies with the ratio $r$, it being less for the smaller ratios. Thus, for $r = 30$ the tensile stress in steel is 12,100 lb., and for $r = 60$ the same stress is 18,300 lb. per square inch. The conclusion to be drawn from this is that in a locality where the price of concrete is high it is more economical to use plain rods of medium steel, providing the shear, bonding and adhesion are taken care of. The writer in all his work has used twisted rods of high elastic limit. The tests made at Columbia University have shown that the elastic limit is increased 25 per cent. after the rod has been twisted.

It is, therefore, neither correct nor economical to use the same percentage of reinforcement in all cases, but the engineer has to consider his own case as to conditions of cost, assumed moduli of elasticity and allowable stresses in concrete and steel, and thus figure up the cost per lineal foot of beam. A table similar to that given below will show what percentage of reinforcement will give the least cost and also the corresponding stress in steel.

The costs in the following table are based on a concrete price of $10 per cubic yard in place and steel 3 cents per pound in place.

| Percentage of steel. | Cost per lineal foot of beam. | Stresses in steel. Lb. per sq. in. |
|---|---|---|
| 0.1 | $0.685 | 45,500 lbs. |
| 0.2 | 0.611 | 31,600 " |
| 0.3 | 0.585 | 25,300 " |
| 0.4 | 0.580 | 21,650 " |
| 0.5 | 0.574 | 18,750 " |
| 0.6 | 0.568 | 17,100 " |
| — | — | — |
| 0.7 | 0.571 | 15,300 " |
| 0.8 | 0.578 | 14,100 " |
| 0.9 | 0.583 | 13,300 " |
| 1.0 | 0.589 | 12,400 " |

The percentage giving minimum cost is in this case 0.6 and the corresponding stress in steel 17,100 lb. per square inch.

## Leakage through an Earth Dam.

Leakage through an earth dam with a concrete core wall, built in 1903, at Lynn, Mass., has been investigated by Mr. Wm. S. Johnson, of Boston. A description of this dam and the method of building it was printed in The Engineering Record of Dec. 19, 1903. It is about 2200 ft. long, 52 ft. wide at the crest, and 200 ft. wide at the base at the deepest point. It has been designed so that its height can be raised 20 ft. at some future date. An old dam which was in good condition was incorporated in the new structure, forming the lower part of the upstream face. After water had been admitted to the reservoir, seepage appeared in many places, and accordingly an examination of the structure was ordered. Mr. Johnson found that the largest single leak was at the rate of about 2800 gal. a day. This occurred when the water level was 7½ ft. below the level for which the dam was intended. When the water was drawn down about 5 ft. this leak entirely disappeared, being the only one to disappear completely with the lowering of the water level. Mr. Johnson states that the distribution of the leakage throughout practically the entire length of the dam, and the absence of any large streams at any one place indicates that even when the pond is full, there will be no cause for alarm. The total leakage was probably from about 239,000 to about 418,000 gal. per day, depending on the water level in the basin.

Iron Ore Production in the United States in 1907, according to the U. S. Geological Survey, probably reached a total of from 52,000,000 to 54,000,000 long tons.

## The New Mill of the California Portland Cement Company.

The California Portland Cement Co. has recently placed in operation at Colton, Cal., 55 miles east of Los Angeles, a new cement mill, with a capacity of 2,500 barrels a day. This company also operates another mill at Colton, which is the pioneer mill on the Pacific Coast and one of the earliest to be built in this country. The capacity of this original mill is 500 barrels a day, but the output has for some years been insufficient to supply the demand for the cement produced. Consequently, the construction of the new mill was started adjacent to the original one in March, 1907, and is now practically finished.

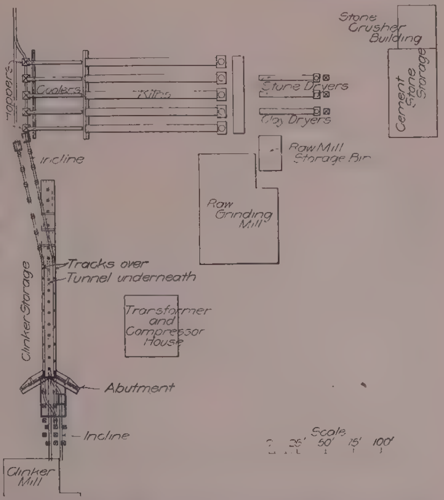
The original mill is on the north side of a hill of nearly pure limestone rock that rises to a height of 500 ft. above the valley in which it is located. The new mill is on the opposite side of this hill, about a mile from the original one. The deposit of rock in the hill is unusually pure and high in lime, so clay is added to produce the proper mixture of raw materials. This clay is obtained from a deposit about 20 miles distant and is delivered over switch connections with the Atchison, Topeka & Santa Fe R. R. Both mills also have switching connections with the Southern Pacific and the San Pedro, Los Angeles & Salt Lake railroads, so that all of the shipping facilities in Southern California are directly available.

The new mill is just above the base of the hill, where advantage can be taken to considerable extent to handle the materials through the mill by gravity. The equipment of the mill is driven entirely by individual alternating-current motors supplied with three-phase 50-cycle 440-volt current. Power to operate the mill is obtained from the Los Angeles Edison Co. and is delivered at 33,000 volts, from which voltage it is stepped down to the operating voltage by transformers in the mill.

View of the Mill of the California Portland Cement Company, from the Down-Hill Side.

The quarry from which the rock is obtained is in a bench cut in the side of the hill, well above the mill. All of the rock in the quarry requires blasting. The loosened rock is loaded into end-dump steel-body cars, having a capacity of 80 cu. ft. each, and is delivered by hand on a down-grade 3.5-ft. gauge track to a tipple at a crusher house. The cars are dumped at this tipple by a compressed-air hoisting cylinder suspended from a gallows frame over the track. The piston rod in this cylinder carries a hook, which when attached to the rear end of the car, hoists that end so the rock is discharged at the front end into a chute leading down into the crusher house. This arrangement, although simple, is particularly effective. The empty cars are hauled back to the quarry by a horse.

The crusher house contains two gyratory crushers, a No. 6 Gates and a No. 6 Austin, into either or both of which the quarry rock can be discharged by gravity from the tipple. Each crusher delivers into the boot of a vertical, continuous-bucket elevator, 46.5 ft. between centers of the end pulleys. This elevator raises the crushed stone to an overhead horizontal drag conveyor, which extends over a rock-storage bin adjoining the crusher house. Each crusher is belt-driven by a 75-hp. continuous-speed motor; the elevator for each crusher is driven through sprocket chains, and the drag conveyor through a rope drive by the motor driving the crusher.



General Arrangement of Mill Buildings.

The rock storage bin is 40 x 80 ft. in plan and 15 ft. deep, having a capacity of 5,000 tons. It has 10-in. reinforced-concrete side walls and is covered with a galvanized iron roof. The two drag conveyors which deliver the output of the crushers to the bin are arranged to discharge at various points in the latter. The crushed rock can be drawn by gravity through eight gate openings in a row at the same level along the bottom of the down-hill side of the bin. These gates discharge on two horizontal conveyor belts, one of which travels from one end and the other from the opposite end of the bin, toward the transverse center line of the latter, each serving four gates. These two horizontal conveyors deliver to an inclined belt conveyor, 45 ft. long, which elevates the crushed rock to a dryer house.

The dryer house contains three 5 x 50-ft. rotary dryers placed together in a row, two for crushed stone and one for clay. The inclined belt conveyor leading into the house from the rock storage bin delivers crushed rock at the top to either or both of two hoppers supplying two of the dryers. The clay is dumped from the railroad cars in which it arrives into a storage area under a trestle adjoining the dryer house, the floor of this area being about 15 ft. below the floor over the charging end of the dryers. The clay is reloaded from the pile, as required, into 1-yd. Koppel steel-frame and steel-body dump cars, which are hauled up an incline by a cable on a hoisting drum in the dryer house and are dumped into a hopper supplying the third rotary dryer. All three dryers are geared to a line shaft belt-driven by a 30-hp. continuous-speed motor, friction clutches being provided so any one dryer may be operated without relation to the other two. The same motor also drives the hoist used to haul the cars of clay up to the charging floor, and a screw conveyor by which large lumps of clay which pass through the clay dryer may be returned to the charging hopper again. The dryers are all arranged to operate on waste heat fom the cement kilns, each being served by a 3.5 x 60-ft. steel stack on a reinforced-concrete base.

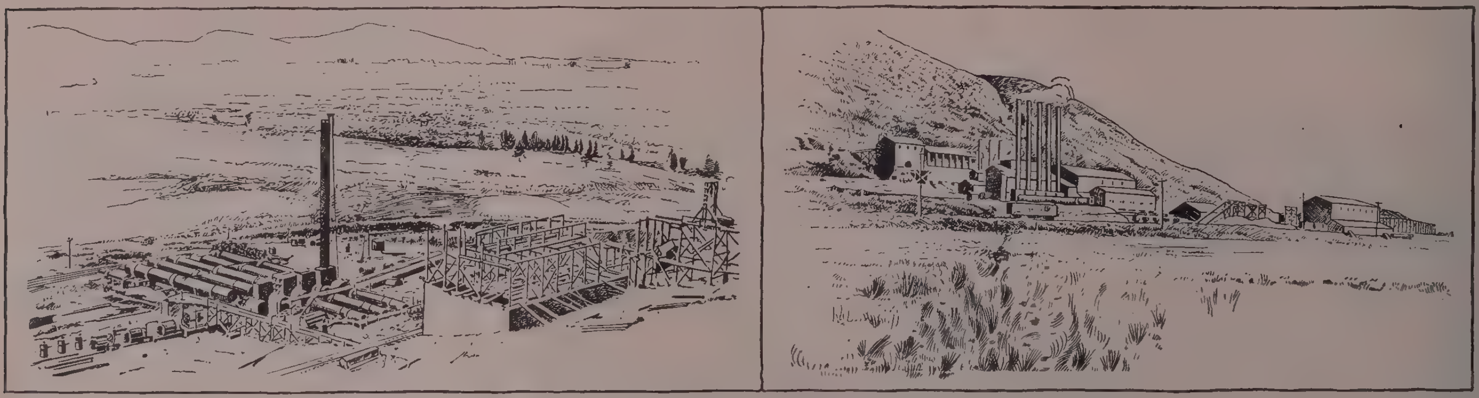
A vertical bucket conveyor is provided at the discharge end of each dryer to elevate the output of the latter to an overhead horizontal flight conveyor leading to dry-materials storage bins in the raw-grinding building, which adjoins one side of the dryer house. The elevators serving the two stone dryers both discharge into an overhead flight conveyor, which is 72 ft. long and delivers to a 500-ton elevated storage bin in the raw-grinding building. The clay elevator is also served by a separate flight conveyor, which delivers to an elevated storage bin adjoining the dry-rock storage bin. The three elevators and the two flight conveyors are driven from a line shaft belted to a 50-hp. continuous-speed motor. The elevators are driven from this shaft by sprocket chains and the conveyors are geared to jack shafts, a friction clutch being provided at each unit.

The elevated dry-stone and dry-clay bins have side and ends built of 2 x 6-in. plank, laid flat in crib fashion, and are on a heavy monolithic concrete base. A reinforced-concrete tunnel extends longitudinally under this base at an elevation that brings the floor in the tunnel above the floor of the building. A 2-ft. gauge track is laid in this tunnel, the latter being 40 ft. long and of sufficient cross-section to permit a 1-yd. steel-frame and steel-body Koppel dump car to be operated in it readily. Dry clay is drawn into this car through under-cut gates in the bottom of the clay storage bin, and is trimmed to a predetermined weight on platform scales at that end of the track. The car is then shunted under the dry-rock bin, where it is filled with crushed stone through any of four under-cut gates in the bottom of that bin; when filled, the car is pushed to a second platform scales at the other end of the tunnel track and there trimmed to the proper weight to produce the necessary proportions of clay and stone.

The proportioned loads are dumped from the tunnel car into the boot of a vertical bucket elevator of the continuous-bucket type, which is close to the second platform scales. This elevator discharges on a horizontal belt conveyor extending over a row of three No. 8 Allis-Chalmers ball mills. The elevator and conveyor are driven by a 20-hp. continuous-speed motor; the elevator is directly driven by a sprocket chain on a jack shaft belted to the shaft of the motor, and the conveyor is gear driven from a line shaft.

This horizontal belt conveyor is arranged so part or all of the materials handled by it may be delivered at three different points to supply bins over the ball mills. The latter are fitted with screens having ⅜ x ½-in. slotted holes, permitting them to be operated at high speeds and to large capacity. Each mill is belt-driven by an individual 50-hp. continuous-speed motor; the three motors are on a raised concrete floor in the rear of the mills, where each of them is provided with a starting box and resistance.

The ball mills discharge directly into a screw conveyor placed longitudinally in the concrete base on which the three mills are mounted. This conveyor delivers to the boot of a vertical high-speed bucket elevator, which raises the material to an overhead horizontal screw conveyor extending across to a longitudinal screw conveyor over a row of ten Fuller-Lehigh pulverizer mills on the opposite side of the building from the ball mills. One 30-hp. continuous-speed motor drives the screw conveyor under the row of ball mills, the high-speed bucket elevator and the two overhead screw conveyors. The lower screw conveyor and the elevator are driven by sprocket chains on jack shafts, while the two overhead conveyors are geared to shafts driven by the motor. Each unit of this group of conveyors is arranged so it can be thrown out of service by a friction clutch.


Rock Storage, Dryers and Kilns under Construction, and General View of New Mill.

The row of ten Fuller-Lehigh pulverizing mills is directly across from and parallel to the row of ball mills. The longitudinal screw conveyor over the pulverizing mills is arranged to discharge to any or all of the latter through down spouts. Each of the mills is belt-driven by a 50-hp. continuous-speed motor, the ten motors being in a row at the rear of the row of mills, where they are each provided with a separate starting box. The belt pulley on the shaft of each motor is 15 ft. on centers from the driving pulley of the corresponding mill; the 14-in. belts used to transmit power from the motors to the mills are operated satisfactorily with a quarter turn in this short reach. The motors run at 700 r. p. m. and the mills at 210 r. p. m.

The rather coarse product of the ball mills, as equipped, is ground by the pulverizing mills to an average fineness of 86.2 per cent. through a 200-mesh sieve and 97.7 per cent. through a 100-mesh sieve. The mills discharge into a screw conveyor laid longitudinally under the row of mills. This conveyor delivers into a high-speed perfect-discharge bucket elevator at the end of the row of mills, which elevator raises the pulverized raw materials to a screw conveyor extending over a row of elevated supply bins at the charging end of the cement kilns. This group of conveyors is driven by a 30-hp. continuous-speed motor, with drives arranged generally the same as those of the group at the end of row of ball mills, permitting each unit to be operated independently.

The raw-materials supply bins at the charging end of the cement kilns are directly in front of the discharge ends of the rotary dryers, the materials making the circuit from the dryers through the raw-grinding building and back to these bins. The latter are built of reinforced concrete and have a capacity of 350 tons. At each of the five cement kilns supplied from them a transverse tunnel is placed under the bins, with the tunnel arch above the level of the bottom of the charging ends of the kilns. A cross screw conveyor, fed from three gates in the bottom of the bins, is placed in each of these transverse tunnels and discharges into a second screw conveyor leading into the kiln. The second conveyor travels at twice the speed of the first, to avoid any danger of choking the kilns. The conveyors to each kiln are driven by the same motor which drives the kiln, so the supply of materials is varied automatically with the speed of the kiln.

The five kilns provided are 120 ft. long and taper from an inside diameter of 7 ft. at the charging end to 7.5 ft. at the firing end. They were built by the Vulcan Iron Works, of Wilkes-barre, Pa., and are placed side by side in a row, in the usual manner. The charging ends are in a reinforced-concrete base for the stacks which serve the kilns, and the firing ends are surrounded by a building, but otherwise the kilns are not enclosed. Each kiln has three ring bearings mounted on concrete piers and is gear-driven from a line shaft belted to a 30-hp. variable-speed induction motor placed under the kiln near the transverse center line of the row.

The five steel stacks which serve the kilns are each 100 ft. high above the base and 5.5 ft. in diameter inside the brick lining, which is carried up 50 ft. above the base. The latter is 25 ft. high and 8 x 10 ft. in plan. Although the top and sides of the base are 10-in. reinforced-concrete slabs and the large openings for the kilns and stacks had to be left in them, the stacks are carried by this base without any evident signs of failure.

The building over the discharge or firing ends of the kilns is 20 x 75 ft. in plan and had a 4-in. reinforced-concrete floor, placed about 5 ft. above the ground level. The hoods of the kilns are each mounted on a four-wheel truck that runs on a 5.5-ft. gauge track laid in the reinforced-concrete floor, a 10-in. beam being placed under both rails of this track. The floor in the rear of the kilns is clear so the hoods can be pulled back on the tracks readily to permit the kilns to be entered for repairs.

The kilns are fired with crude fuel oil, which is supplied at a pressure of 65 lb. per square inch at the feeding nozzle and is blown into the kiln by an air blast under a pressure of 95 to 100 lb. per square inch. The oil is preheated to 120 deg. Fahr. immediately before being fired, by passing it through pipes in a jacket over the end of the kiln. The operation of the firing feeds and of the motors driving the kilns is all controlled from the floor which carries the ends of the kilns.

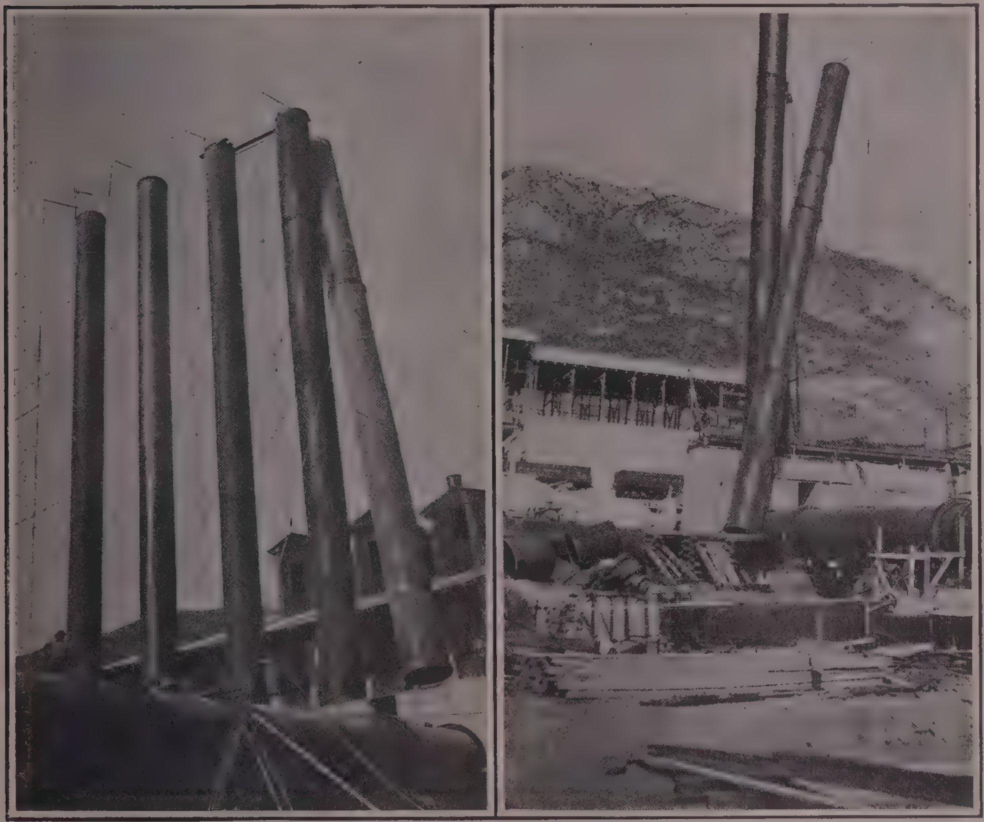
The crude oil used for fuel is stored in a covered concrete tank placed at one side of the mill buildings. This tank is 30 x 300 ft. in plan and 12 ft. deep and has a capacity of nearly 24,000 barrels. A 4 x 6 in. duplex motor-driven pump delivers the oil from this tank to the kilns. From experience with oil-storage tanks built of concrete at the original mill of the company and at a marble-cutting works which occupied the site of the new mill, it is evident that the concrete in these tanks was certainly not damaged in any way by the oil during years of service, but was apparently much improved in strength.

Each of the kilns discharges the clinker into a 3 x 50-ft. rotary cooler. The five coolers were built by Vulcan Iron Works and are placed in a row, with their ends under the reinforced-concrete floor on which the ends of the kilns are carried. The ends of the coolers into which the clinker is fed from the kilns are closed, and a stream of water is applied continuously at that end to the hot clinker. The resulting steam and gases are blown out of the other end of the cooler by a blast of air applied with the water. The five coolers are all gear-driven from a line shaft belted to a 30-hp. continuous-speed motor; this shaft is arranged with friction clutches so the coolers may be driven independently.

The clinker is discharged from each of the coolers into a 2-yd. steel hopper. the five hoppers being in a row over a narrow-gauge track at right angles to the axes of the coolers. This track connects with two other tracks which extend up on a 40 per cent. grade to a steel trestle erected over a 50,000-ton clinker storage pocket adjacent to the coolers. This trestle also carries two tracks and is at a height of 30 ft. above the floor of the pocket. The latter has a concrete floor 90 x 120 ft. in plan; a reinforced-concrete abutment, with wing walls, is placed at each end of this floor to confine the clinker. The clinker is loaded into 1-yd. steel frame and steel-body Koppel dump cars from the row of hoppers at the end of the coolers, and the cars are hauled up one track of the incline by a link-belt car hoist chain-driven by a motor at the top of the incline. When the cars reach the trestle they are readily pushed along the latter by hand, as the loaded-car track is on a descending, 0.66 per cent. grade. After a car is dumped at any point over the pocket it is shunted at the end of the trestle to the other track, which is on a 1 per cent. grade descending toward the incline. At the head of the latter the empty car is placed on a chain the same as the one in the ascending track and delivered to the foot of the incline.

A tunnel large enough in cross-section to permit 1-yd. dump cars to be operated in it is placed longitudinally under the middle of the clinker storage pocket. The clinker can be drawn into 1-yd. cars on a track in this tunnel through eighteen under-cut gates in the floor of the storage pocket. These cars are hauled up a double-track incline leading to the second floor of a 73 x 163-ft. cement-grinding building by a link-belt hoist arranged the same as the one at the other end of the storage pocket.

The clinker is discharged from the cars in the cement-grinding building into a supply bin over a row of three Allis-Chalmers ball mills. After passing these mills the clinker is finely ground in a row of fourteen Fuller-Lehigh pulverizing mills, the cement having a fineness of 99 per cent. through a 100-mesh sieve and 87.7 per cent. through a 200-mesh. The arrangement of all the equipment and conveying apparatus in this building is the same as that in the raw-grinding building. The screw conveyor under the row of pulverizing mills delivers to a high-speed perfect-discharge bucket elevator, which discharges on a screw conveyor extending over bins in a 60 x 260-ft. cement-storage building adjoining.



Views of Erection of the Kiln Stacks, California Portland Cement Co.

The floor of the cement-storage building is of concrete, laid directly on the ground. The sides of the ten bins into which the interior is divided are built of 2 x 6-in. plank, laid flat. Each of these bins has a capacity of 6,000 barrels, making the combined storage capacity 60,000 barrels. A platform, 10 ft. wide, is provided along both sides of the row of bins, and a portable sacking machine is moved along these platforms to any of the bins, as desired. The sacked cement is loaded directly from the platforms into cars on switch tracks along both sides of the building.

All of the conveying equipment in the entire mill is of standard sizes, capacities and speeds. The conveying belts are 20 in. wide and are arranged to run at a speed of 200 ft. per minute. The perfect-discharge bucket elevators, operating at 300 ft. per minute, are all of one size. The screw conveyors are uniformly 12 in. in diameter and operate at 75 r. p. m., except those feeding the cement kilns. All of the conveying apparatus, except the conveying belts, is thoroughly enclosed, which arrangement, combined with the type of grinding equipment installed, reduces the amount of dust in the air to a minimum. The conveying belts were built by the Robins Conveying Belt Co. The balance of the conveying equipment was built by the H. W. Caldwell & Sons Co. The motors throughout the mill were built by the Allis-Chalmers Co. and are designed specially to operate in the dusty surroundings.

The compressed air required in various parts of the mill is furnished by two compressors in a separate building near the kilns. These compressors are of the two-stage cross-compound Ingersoll-Rand type, each with a capacity of 1,040 cu. ft. of free air a minute delivered against a pressure of 100 lb. per square inch when operating at 158 r. p. m. Each compressor is belt driven by a 200-hp. continuous-speed Fairbanks-Morse induction motor and has sufficient capacity to supply the demands of the mill. This building also contains four 1,000-kw. water-cooled Wagner transformers, in which the incoming 33,000-volt current is stepped down to 440 volts for distribution through the mill. Space is also provided for two additional 1,000-kw. transformers to provide for increased capacity of the mill. The incoming high-tension line is carried on poles, while the power distributing circuits are all in conduits laid underground to and through the various buildings.

The construction of the mill was started in March, 1907, and the first kiln was fired in November last, while the entire mill was practically completed in ten months after construction was commenced. This rapid progress is specially noteworthy, in light of the fact that all of the equipment was purchased in the East, and deliveries across the country by freight are exceedingly slow and uncertain. The large volumes of concrete used in the construction work were made in a single ¾-yd. Ransome mixer mounted on a portable frame. Broken stone for the concrete was furnished by one of the crushers of the mill, which was installed temporarily to deliver to a belt conveyor that discharged into a rotary screen.

Since the mill is considerably isolated, various expedients had to be adopted during the progress of the construction. Among these was the erection of the five tall steel stacks serving the cement kilns. The steel shell of these stacks was delivered at the site in rings 6 ft. wide. The rings of the first stack were erected in place, one at a time, by using a small gin pole, which was lashed to the portion of the stack already built and then hoisted as the stack increased in height. The remainder of the stacks were assembled complete on the ground and each hoisted into place by using the last one erected in each case as a gin pole. The steel shell of each stack weighed 9 tons, but the stacks were all erected in this manner without mishap, each stack requiring about 9 hr. to set.

The officers of the California Portland Cement Co. are as follows: Messrs. Dan. Murphy, president; G. E. Bittinger, vice-president, and T. J. Fleming, secretary and general manager. The mill was designed by Prof. R. C. Carpenter, of Ithaca, N. Y. Mr. E. Williamson Miller was superintendent; Mr. R. H. Huber, engineer, and Mr. Geo. L. Nicholas, general foreman, during the construction, which was handled by the forces of the company. Mr. W. W. Welsh is superintendent in charge of the operation of the mill; Mr. H. C. Knapp is superintendent of power, and Mr. W. C. Hanna, chemist.

## A Concrete-Block Fire Test.

A concrete-block fire test of an exceptional nature was recently afforded by a fire which took place in a three-story building owned by the Gospel Trumpet Co., of Anderson, Ind. On Dec. 9 the interior of this structure was completely destroyed by a fire started by an incendiary. The building was new, having been completed only about ten days, and was not filled with the contents for which it was intended. This probably did not make the fire so hot as it would have been had the structure been occupied, but on the other hand no water connections had been made and it was difficult to get water on the fire in time to check it to any extent. The interior of the building was completely destroyed, the only thing left standing being a steel beam supported by a steel post. The concrete blocks, however, were not injured and there is no necessity of rebuilding any portion of the structure in which they were used. Over a few windows where the flames burst forth, it will be necessary to clean the faces of the blocks, but elsewhere they show no signs of any sort of the fire. The blocks were made on a Hercules machine using a very wet mixture, much wetter than it is customary to employ in block making. It is considered that the dense texture of the concrete resulting from this procedure was largely influential in producing the excellent showing made by the blocks in this fire.

A Brick-Faced Dam is the most interesting feature of the new water works of Swanzy, Wales, which were recently put in service. The dam is a masonry structure, 1250 ft. long, 144 ft. in maximum height from foundation to crest, and 13½ ft. wide on the crest. The upstream face is vertical for 70 ft. from the top and battered 1 in 20 below this; the downstream face is vertical for 15 ft. and then curved to a maximum width of 75½ ft. The dam is built of concrete and faced throughout with blue Staffordshire bricks.

## Difficult Shaft Sinking.

The difficulties attending the opening up of new collieries in a country like England, where the best fields have been worked for many years, were outlined in a paper by Mr. J. J. Priest on "Shaft-Sinking at the Horden Colliery, Southeast Durham," read before the Institution of Civil Engineers on Feb. 18. The southeastern portion of the Durham coal fields is covered by magnesian limestone and so-called yellow sands and the large volumes of fresh and brackish water encountered in sinking through these measures constitute the chief cost and difficulty in the winning of coal in this area.

The Horden Collieries, Limited, was formed in 1900 to win and work about 18,000 acres of coal in the southeast portion of the county, half the area being under-sea coal. The scheme for developing this coal property was to open two new collieries adjacent to the sea coast, at Horden and Hesleden, respectively, and to re-open and equip Shotton and Castle Eden Collieries, with the object of ultimately producing 10,000 tons of coal per day. Half the scheme has now been completed, and this paper has reference mainly to the shaft-sinking operations which have been in progress at Horden.

Having in mind the possible legislative interference with the hours of underground labor, it was decided to sink three shafts—two 20 ft. and one 17 ft. in finished diameter. It was also decided to purchase eight sets of common bucket pumps, each working-barrel to be 30 in. in internal diameter, and each set 50 fathoms in length; to adapt two of the proposed winding engines into four temporary geared pumping engines; and to couple two sets of pumps on to each.

Taking advantage of a difference of level of about 200 ft. between high-water mark and the surface of the shafts, a water-delivery drift was driven from the sea coast a distance of about 600 yd., cutting the shafts at a point about 30 fathoms below the surface. This drift not only enabled the water to be delivered from the pumps at a point 30 fathoms below the surface, whence it gravitated to the sea, but also enabled the coal measures to be reached by means of a single high and low-lift set of balanced pumps on each pumping engine.

Each shaft was equipped with a 30-ton main crab-engine, sinking-engine and jack-engine, and each pair of pumps was suspended by 5-in. diameter plow-steel non-twisting ropes passed round two-fold blocks, the free ends being carried to a 12-ton ground crab-engine fitted with two clutch-geared drums in the usual manner. Each pumping engine consisted of a tandem compound pair of cylinders 21 and 36 in. by 60 in., set on a wrought-steel built-up bed frame, and geared 3-to-1, by means of steel helical gearing, to a second-motion shaft fitted with a steel pumping disk arranged so as to permit the stroke of the pumps being varied from 4 to 6 ft. to suit the volume of water in the pit bottom; the steam pressure available being 160 lb. per square inch.

One pumping engine with two sets of 30-in. pumps was put down at the north shaft, two pumping engines with four 30-in. sets at the south shaft, and one pumping engine with two 30-in. sets at the east pit, all duplicated throughout.

The north shaft was begun Nov. 6, 1900, and was finished 20 ft. in diameter down to the Hutton Seam level, at a depth of 419 yd., on July 23, 1904, after passing through 155 yd. of boulder clay, magnesian marl and limestone, 48 ft. 10 in. of soft gray sand below the latter, and 248 yd. of ordinary coal measure strata. During this period the maximum feeders of water pumped from the shaft with one pair of 30-in. pumps was 4,650 imp. gal. per minute, and 1,500 to 2,000 imp. gal. per minute whilst sinking through the soft gray sand below the limestone at a depth of 188 yd. To dam feeders back into their natural channels, 106 yd. of cast-iron tubbing ⅞ to 1⅜ in. in thickness was put in, and 313 yd. of 14-in. walling in addition, in order to make the sides of the shaft secure.

The south shaft was commenced on Feb. 28, 1901, and was completed 20 ft. in diameter down to the level of the main coal seam, at a depth of 302 yd. on Sept. 1, 1905, after passing through 158 yd. of boulder clay, magnesian marl, and limestone, 39 ft. 2 in. of soft gray sand, and 131 yd. of coal measures.

During this period feeders of water amounting to 6,310 imp. gal. per minute were encountered and successfully tubbed back in the limestone, and 1,200 imp. gal. per minute in the sand. One pair of 30-in. bucket-pumps handled the feeders without difficulty, the duplicate pair being utilized in cases of emergency, and more particularly when passing through the sand. There were 121 yd. of cast-iron tubbing ⅞ to 1⅜ in. in thickness fixed in position, and also 180 yd. of 14-in. walling to secure the shaft sides.

The east shaft was commenced Sept. 3, 1900, and was completed 17 ft. finished diameter, down to a depth of 406 yd. on Nov. 6, 1905, after passing through 152 yd. of boulder clay, magnesian marl and limestone, 61 ft. 9 in. of soft gray sand, and 234 yd. of coal measures.

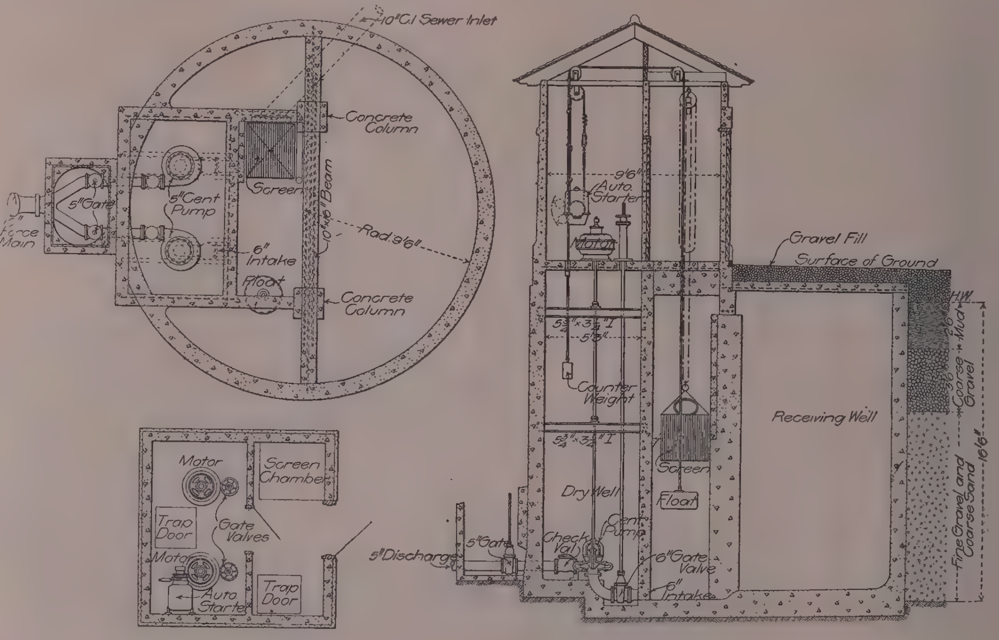
During this period the maximum feeders of water encountered and pumped by one pair of 30-in. bucket-pumps was 6,100 imp. gal. per minute from the limestone, and 3,200 imp. gal. per minute from the sand. There were 115 yd. of cast-iron tubbing placed in position to keep back the feeders of water, also 291 yd. of 14-in. brick walling to secure the shaft sides. Owing to the soft character of the sand this shaft had to be piled, and the time actually occupied in sinking and safely securing the pit into the coal measures from a depth of 152½ yd. down to 178 yd. was 27 weeks.

The maximum feeders of water pumped simultaneously at any one period amounted to 9,230 imp. gal. per minute, from the east and south shafts, from Sept. 23 to Nov. 26, 1903. The actual volumes of water pumped were measured daily at noon by means of a large tank suitably arranged for the purpose at the outlet end of the delivery-drift. The production of coal from this property is now averaging 1,000,000 tons per annum.

## Electrically Operated Automatic Sewage Pumping Station at Waltham, Mass.

By Bertram Brewer, City Engineer and Superintendent of Sewers.

The writer has recently built for the city of Waltham, Mass., and is operating automatically, an isolated sewage pumping station. A low-lying district of 30 acres across the Charles River from a well from which the city's water supply has been taken for 34 years, has been gradually built upon so as to become a menace to the purity of the water. Two methods of caring for this sewage were possible: one involved an outlay of $60,000 for a sewer 5,600 ft. long along the river bank, mostly on private land, to a point below a dam, where existing sewers are low enough to receive the flow from this low area by gravity; the other plan, which was adopted, provides for an automatically operated pumping station to lift the sewage about 30 ft. through a force main 630 ft. long into an existing main on a higher level. This plant was erected at a cost of $7,000, and, judging by three months of use, will cost about $350 annually to operate.



Automatic Sewage Pumping Station at Waltham.

The storage well is 19 ft. in diameter and 17 ft. deep. It was built of plain concrete with 10-in. walls. This well is about 50 ft. from the Charles River and below its level except for the upper 2 ft. It is absolutely waterproof; there is neither leakage nor even seepage. Every precaution was taken to get the very best possible materials and mixture and hydrated lime was used to increase the impermeability of the concrete. We met with absolute success.

The accompanying photograph shows the method of bracing this well. Four-foot poling boards were used to hold up the bank, while from 4 to 8½-in. boards, nailed one over the other to complete the circle, provided the necessary ribs. This method of bracing was very economical and proved very successful. The material encountered was a clayey gravel and therefore stood up fairly well until a set of boards and ribs could be erected. This well has a reinforced concrete roof with a dry pump pit built in it to contain the pump and shafting. A house for the screen and motor rooms is built over the well and pump pit.

The plant consists of two units, two 5-in. vertical centrifugal pumps directly connected with 15-h.p. vertical motors.

As has already been intimated, the sewage, as it enters the storage well, passes through a screen which removes the larger particles and more especially the cotton waste. The pumps will be always primed, as they are placed at the bottom of the well in a dry pit, with the entrance to the suction pipe, which is very short, so located that all the harder materials are frequently stirred up and constantly removed.

After careful investigation into the merits of the various automatic starting and controlling devices for alternating current motors now on the market, we decided upon the one designed by the Westinghouse Electric & Manufacturing Co. The automatic controller consists of a sheave or hollow drum, a weight on the end of a lever, two spiral springs, and a pawl arrangement for regulating the action of the springs.

Sheeting for Well of Sewage Pumping Station at Waltham.

A sheave is mounted loosely upon the shaft; an iron ring, cast on the side of the sheave, has a slot cut in it, through which passes the arm carrying the weight. This weight arm is also free to move on the shaft. The slot in the sheave-ring is just long enough to allow the weight arm to fall from the vertical to the resting place, an arc of 125 deg., so that when the sheave is turned through a distance of 125 deg. the weight will be lifted to the perpendicular and allowed to fall an equal distance in the opposite direction. When the weight falls, the weight arm engages two spiral springs, which are coiled loosely around the shaft. These in turn press against a casting which is keyed to the shaft, but which is prevented from turning by a pawl, which is held by notches in the main casting. The weight arm compresses the springs, and then trips the pawl and the spring moves to the next notch. The pawl is tripped three times during the downward motion of the weight, and each time it is tripped, it allows the shaft to be turned a certain distance by means of the compressed springs, and the shaft in turning operates the auto-starter, throwing it through the three notches to the full running position. When the weight falls in the opposite direction, the auto-starter is thrown to the off position.

The time of the fall of the weight is controlled by means of a dash pot, situated at the end of the weight-drum bearing.

The float mechanism, while very simple in design, at first was a source of considerable annoyance owing to the constant variations in temperature inseparable from an unheated, isolated plant. The control rope was necessarily long and its length therefore was materially affected by changes in temperature and when too loose or too tight would not operate the controller. The difficulty was overcome by inserting a heavy spring in this control rope. This difficulty overcome and the weights of float and counterweight made ample to furnish the necessary power to lift the weight arm on the controller and overcome the considerable amount of friction in the apparatus itself, the operation has proved reliable under the trying conditions of the current winter.

As a further precaution, a Winslow recording apparatus has been installed, with dials and weekly record of pumping, both at the office and at the sewer yard in the foreman's house. This gives those in charge ample notice of any abnormal conditions which may occur at the pumping station.

The accompanying drawings show the well and house and the arrangement of the mechanism. Fortunately this plant is operated by those who are interested to save the city's money and make it a success. We are satisfied that it will require only an occasional inspection and an intelligent care of its various parts.

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A SEMI-AUTOMATIC GAS ENGINE of novel design has recently been devised, involving the application of valve mechanism of the detachable or "hit-and-miss" type, to the exhaust valve, the gear being spring-retained in unlatched or non-operative position ordinarily, so that unless specially actuated the valve does not open to exhaust on the exhaust stroke. The spring holding the latch or dog, is attached to a piston in a miniature cylinder connected into one side of the main engine cylinder at such a point near the crank end that the engine piston uncovers the opening at its extreme outer stroke only and admits the pressure of the exploded gases to it. The movement of the exhaust valve push rod is so timed in relation to the admission of pressure to the miniature cylinder that the latch which is forced out by the latter is caught and causes the exhaust valve to open for the regular exhaust function; if, however, the explosive mixture shall not have exploded, due to omission of spark for speed regulation, the miniature piston is not actuated and the explosive charge is not exhausted and wasted as with the usual gas engine construction. Engines of this construction are said to regulate very closely and show a favorable fuel consumption for the small sizes of units.

## The United States Geological Survey's Hydraulic Laboratory at Berkeley.

At a recent conference of the district engineers of the Water Resources Branch of the U. S. Geological Survey, Prof. G. K. Gilbert explained the features and purposes of the novel laboratory instituted at Berkeley, Cal., in connection with studies of what is known as the mining débris problem of the Sacramento-San Joaquin basin. Its conduct is in the immediate charge of Mr. E. C. Murphy, space, power, and other facilities being furnished by the University of California. The following abstract of his remarks at the conference regarding the laboratory has been furnished by Prof. Gilbert:

The maximum detrital load of a stream is a function of (1) the discharge, (2) the slope of water surface and channel bed, general and local, (3) the character of the detritus, including size, shape, and density, (4) the form of cross-section, general and local, (5) the ground plan of channel, (6) heterogeneity of flow, or the deviation of flow lines from general parallelism and especially from parallelism with the bottom, and (7) the velocity, general and local. All these factors, except the discharge, are intricately interdependent. The form of the function is unknown. It is the purpose of the laboratory to investigate the form of the function and determine some of its more important constants.

The problem first attacked is that of the relation of load to slope, the experiments being so arranged as to eliminate so far as possible the influence of other variables. The discharge is made definite and uniform; the material of the load is sand from the American River, sorted by sieves of definite mesh; the channel is straight, of rectangular cross-section, and of uniform width. To the stream flowing through such a channel sand is fed at a uniform rate; and the experiment is continued until the stream has established a uniform slope by arranging the sand on its bed, and until the rate of sand delivery is the same as the rate of sand feeding. The slope is then measured, together with the mean velocity and bottom velocity. In the next experiment the load is made greater, and the resulting slope is then measured. A series of such experiments gives a curve of the relation of load to slope for the particular discharge, channel width, and size of sand grain, together with the concurrent relation of velocity.

The work is then repeated with a different discharge, and in subsequent series of experiments with different channel widths and different sizes of detritus. Within this general scope important progress has been made, but the results are not yet ready for publication. Eventually it is hoped to investigate the laws of transportation for mixed detritus, for channel beds not wholly covered by material in transit, and for curved channels.

In the apparatus now installed the maximum width of channel is 2 ft. and the maximum length 140 ft.; discharge is regulated by passing the water through a calibrated rectangular opening under a constant head of about 6 ft.; velocities are measured by a specially constructed Pitot or Darcy gauge; sand is fed wet from an irrigated hopper, and is caught through a grating in the bottom of the channel; water slopes are measured by piezometers, and sand slopes by spirit level.

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DIFFICULTIES FROM VIBRATION OF STEAM PIPES have been minimized at the Wanamaker store power plant in Philadelphia by the suspension of certain horizontal runs and U-bends on spring hangers which give the lines increased flexibility and prevent, apparently, a straining effect at the joints that had formerly given trouble. The hangers consist of box-enclosed helical springs on which the weight of the pipe is carried in compression, with turnbuckles in the suspender rods above for adjusting the compression.

## Another Massachusetts Decision Concerning River Pollution.

The Massachusetts Supreme Judicial Court rendered another decision early this year on the pollution of streams, riparian rights and the reasonable use of water courses which emphasizes certain points of earlier decisions on these subjects. The opinion in the case, MacNamara v. Taft, 83 N. E. Rep. 310, was written by Chief Justice Knowlton, and reads as follows:

The defendant owns a mill containing four sets of machinery for the manufacture of satinet cloth. It is upon a small stream which in its natural state is 8 to 12 ft. wide and from 3 to 6 ft. deep. The mill is run in part by water power and in part by steam power. The plaintiff owns a farm containing about 50 acres of land nearly a mile below, through which the stream flows on its way to French River. This bill is brought to obtain an injunction against the pollution of the water by the discharge of noxious matter into it.

The evidence shows that the defendant uses daily, at his mill, a large quantity of oil put upon the material before it is spun, and 180 lb. of soap, 165 lb. of soda ash, 45 lb. of soda salts, 200 lb. of extract of logwood and 43 lb. of blue vitriol in fulling and dyeing his cloth. After these chemicals are put into the fulling mill and taken up by the cloth, the cloth is placed in washers and washed. A large part of the logwood and vitriol, and substantiallly all of the other chemicals, are washed out and discharged into the stream. The effect of this discharge is to make the water dark in color and to give it an oily odor and taste such as to prevent the plaintiff's cows from drinking it, as they are pastured on the banks of the stream below.

The case involves a consideration of the rights of riparian proprietors in regard to the pollution of the waters of a stream by the discharge into it of waste and other noxious substances in the use of it. This subject has often been discussed by this court and by courts in other jurisdictions. It was fully considered with a citation of many authorities in the recent case of Parker v. American Woolen Co., 81 N. E. 468. In that case as in the present, the stream under consideration was substantially unpolluted by manufacturing or other impurities, and was nearly in its natural state except for the acts of the defendant, and was not used under the authority of law for the discharge of sewage or other noxious substances, as some streams are which have been taken and appropriated to such a public use.

The general rule is that every riparian proprietor on a stream has a right to have the water come to him in its natural condition, except so far as it is affected by the reasonable use of their property by the owners above. The doctrine of the decision in Merrifield v. Lombard, 13 Allen, 16, 90 Am. Dec. 172, is correctly stated in the head note as follows: "The owner of land through which a natural stream of water passes has no right to use the water for such purposes as will corrupt it to the material injury of the riparian owners below." Chief Justice Bigelow says: "An injury to the purity or quality of the water, to the detriment of other riparian owners, constitutes in legal effect a wrong and an invasion of private right, in like manner as a permanent obstruction or diversion of the water." In Dwight Printing Co. v. Boston, 122 Mass. 583, the petitioner claimed a right to use the water in bleaching woolen and cotten cloths in such a way as to befoul it and render it unfit for drinking purposes. The court said that it has acquired no such right by prescription, and added: "It is well settled that, as a riparian proprietor merely, it has no such right." The two cases of Walker Ice Co. v. American Steel & Wire Co., 70 N. E. 937, and New England Cotton Yarn Co. v. Laurel Lake Mills, 76 N. E. 231, contain expressions in recognition of this doctrine.

On the other hand there are cases in Massachusetts which recognize the fact that the water in a brook may lawfully be affected both in its quantity and quality by the legitimate use of an upper riparian owner. Merrifield v. Worcester, 110 Mass. 216-219, 14 Am. Rep. 592; Harris v. Mackintosh, 133 Mass. 228-231; Haskins v. Haskins, 9 Gray, 390-392; Washburn & Moen Mfg. Co. v. Worcester, 27 N. E. 664.

Ordinarily, the question whether the use of a stream by an upper riparian owner is reasonable is a question of fact. The reason why such a question is open, in many cases, is that certain uses of a stream which are universally recognized as lawful may diminish the quantity of the water or affect its quality to some extent. The watering of cattle may permanently abstract from the stream so much as they drink. The use of land for the pasturage of cattle may roil the water as they pass through it if the banks and bed of the stream are muddy, or cause the dropping of excrement into it which will slightly affect its quality when it reaches the land of the next owner, just across the boundary line. The cultivation of land may cause earth to be washed into the stream. Such uses, carefully regulated, are not unreasonable, and the right of the owner below is subject to the exercise of these rights by the upper proprietor.

But the questions of fact which arise in determining whether a use is reasonable are limited by certain rules of law. One is that a permanent diversion of a substantial portion of the water, to the detriment of an owner below, cannot be found to be reasonable, although it may be convenient and profitable for the diverter. It is an invasion of a legal right. In like manner the discharge of a noxious substance into the stream in such quantity as materially to affect the purity of the water when it reaches the land of a lower riparian owner, if it interferes with his use of the water, is an invasion of his right of property, and as matter of law is unreasonable. But in a use of a stream, of a kind which is generally recognized among the people and in the courts as legal, a slight impairment of the quality of the water, which is necessary and incident to the use when properly and carefully regulated, is not unreasonable.

These we think to be the rules that are deducible from the cases in Massachusetts and in other states. The case of Richmond Mfg. Co. v. Atlantic De Laine Co., 10 R. I. 106, 14 Am. Rep. 658, is much like the one now before us in its facts, and in it the right of the lower proprietor to have the water come to him unimpaired in its purity is stated strongly. The doctrine is reaffirmed in Silver Spring Bleaching & Dyeing Co. v. Waushusk Co., 13 R. I. 611, and Bradley v. Warner, 41 Atl. 564. The subject is considered elaborately in Lockwood v. Lawrence, 77 Me. 297, 52 Am. Rep. 763. It is said in the opinion that "any diversion or abstraction which substantially and materially diminishes the quantity of water, so that it does not flow as it has been accustomed to, or which defiles and corrupts it so as to essentially impair its purity, thereby preventing the use of it for any of the reasonable and proper purposes to which it is usually applied, is an infringement of the rights of other owners of land through which the stream flows," etc. The same doctrine is laid down in Holsman v. Boiling Spring Bleaching Co., 14 N. J. Eq. 335, and Middlestadt v. Waupaca Starch & Potato Co., 66 N. W. 713. See also, Chapman v. Rochester, 18 N. E. 88.

The cases of Snow v. Parsons, 28 Vt. 459, 67 Am. Dec. 723, Hayes v. Waldron, 44 N. H. 580, 84 Am. Dec. 105, and Red River Roller Mills v. Wright, 15 N. W. 167, are among the most favorable to the contentions of the defendant. The first of these cases was an action for damages caused by the discharge of tan bark into the stream from a tannery above, the second was for discharging sawdust and shavings from the defendant's mill into the river, and the third for discharging sawdust and other refuse from a saw mill into the stream. In each it was held to be a question of fact whether the defendant's use of the stream was reasonable, and in each there is language on the subject which suggests a liberal interpretation of the law in favor of the user. It is to be observed that the cases were all very different from the discharge of noxious substances into a stream, materially affecting the purity of the water as it enters the land of a riparian owner below. The business of each of the defendants was of a kind which is universally recognized as legitimate in the use of a stream, and there was ground for a contention that the damage to the defendant was no greater than might result as an absolute necessity from this kind of use, under careful and proper management.

The case of Snow v. Parsons, ubi supra, is considered and explained in the later case of Canfield v. Andrew, 54 Vt., 1, 41 Am. Rep. 828, in which the court says: "Such damages as are incident to and necessarily result from a proper use of the water must be borne. But the manufacturer has no right to do any act that in its consequences is injurious to others, because it is a matter of convenience or economy for him to do it. It is as much the duty of a manufacturer to so dispose of his waste as not to injure others as it is to refrain from injuring others by any other act. No one is allowed to deposit any substance in a running stream that will pollute its waters to the injury of a riparian owner below."

No discharge of noxious waste, in quantities sufficient noticeably or appreciably to affect the quality of the water in the lands of a proprietor at a considerable distance below, is shown to be necessary in the business of manufacturing cloth, however convenient or profitable it may be to the manufacturer. If filtering the water before returning it to the stream, after using it in the mill, is necessary to protect the rights of the lower riparian owner, or if chemicals or oils should be disposed of otherwise, the mill owner should make provision for it.

In view of its effect upon the use which the plaintiff desired to make of the water, there is no foundation for the defendant's contention that his discharge into the stream of oil, soap, soda, logwood, blue vitriol and other chemicals was reasonable. It was clearly proved that much of the time the plaintiff's cows refused to drink the water, and that thereby she suffered substantial loss and damage.

It is only when the owner in the stream below is materially affected in his right to use the water, by reason of its impurity as it enters his premises, that he has a remedy against the upper proprietor by whose use the quality of the water is impaired. For a slight impairment of quality, necessarily resulting from a reasonable use of the stream or of the land abutting on it, there is no liability. But the rules and principles so fully stated in Parker v. American Woolen Co., ubi supra, forbid the unnecessary discharge of polluting substances into a stream in quantities that appreciably affect the purity of the waters when they reach the premises of a riparian proprietor below, and render them materially less fit for domestic or other uses to which they might be put there than when they came to the land of the owner who is charged with polluting them.

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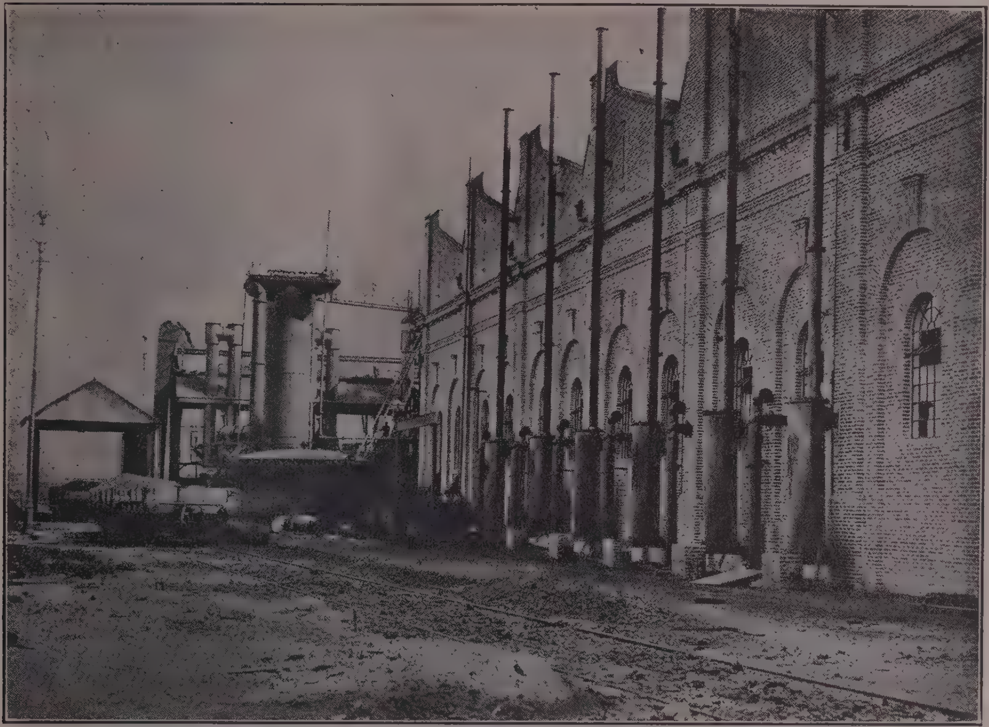
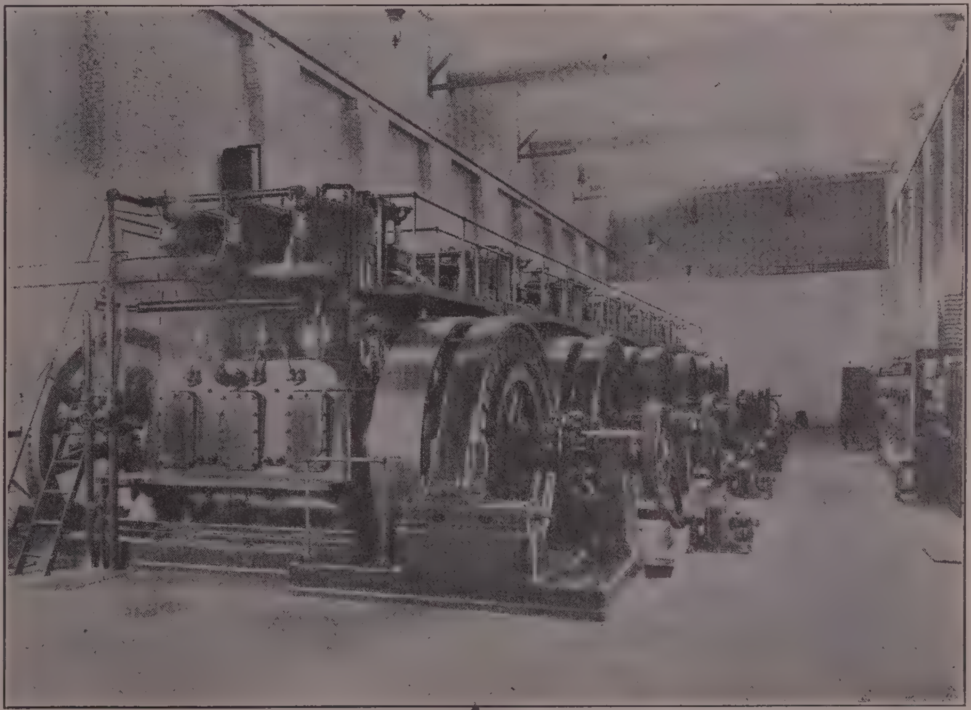
Concrete Pavements are being tried in Frankfort, Germany, on quite an extensive scale. They have not been down long enough as yet to furnish definite information concerning their wearing properties.

## Gas Engine Installations at Buenos Ayres.

Two of the most interesting installations of producers and gas engines in shops on this side of the Atlantic are near Buenos Ayres, one at Banfield belonging to the Buenos Ayres & Great Southern Railway, and the other at Liniers belonging to the Buenos Ayres Western Railway. In both cases Mond producers and Westinghouse gas engines are used, and the energy is distributed electrically for lighting and a great variety of power uses.


Producer Plant and Mufflers at the Banfield Power Station.


Interior of Engine Room of Banfield Power Station.

*Banfield Station.*—This station is centrally located for distributing current for various purposes along a section of the road 12.4 miles in length. There are six Westinghouse vertical, three-cylinder, single-acting gas engines, each having a normal output of 250 h.p., directly connected to Westinghouse, three-phase, 50-cycle, 440-volt alternators of 150 kw. each. The switchboard is of the Westinghouse standard type. From this plant power is distributed by overhead transmission lines to the various workshops and stores departments, offices, etc., at 440 volts for power, and 110 volts for lighting. Westinghouse three-phase, type C induction motors are used throughout the works.

In the locomotive erecting, carriage and wagon shops, groups of lathes, shaping tools, etc., are driven from countershafts belted to motors ranging from 10 to 20 h.p. Individual motors are used for driving sawmill machinery, air compressors, fans, pumps, etc. The shops work eight hours per day and consume about 4,500 kw. during the daily run.

The gas producer plant is designed to supply gas continuously to 1,500 brake horse-power in gas engines by gasifying bituminous slack.

Coal is conveyed by rail to the plant and then dumped into an elevator boot. The elevator, of the bucket type, delivers it into a worm conveyor passing over and delivering into a 25-cwt. coal bunker, one of which is situated over each producer and affords a storage of about six hours' supply. From the bunker the coal passes through a chute into the producer. The producers, of which there are four, are 5 ft. in internal diameter, each resting on a water lute from which the ashes are drawn as found necessary, without stopping the production of gas. Inside each producer is fixed a bell through which coal passes, partly filling it and automatically keeping the level of the fuel in the producer at the same point.

The process of forming gas is, briefly, as follows: A steam-driven Roots air blower supplies air and forces it through an air-heating tower, through which a stream of hot water is passing, and takes up a certain amount of heat and moisture. The air and steam are then conveyed along mains to the superheaters. The superheater consists of two tubes forming an annular space through which the air and steam pass. The hot gases from the producer pass through the inner tube in the opposite direction to the air and steam, and a large amount of heat is transferred from the hot gases to the air and steam. From the superheater the hot air and steam pass through a similar annular space around the producer and downwards through the firebars to the fuel bed. The gas made in the producer comes away from the top of the fuel bed and is carried to the superheater, passing through the inner tube before mentioned.

After leaving the superheater, the gas is taken to a mechanical washer fitted with two dashers. The latter, which revolve at a good speed, throw the water contained in the washer into a fine spray through which the gas passes, thereby being cleaned and at the same time giving up a large amount of heat. The washer is divided into two parts, either of which can be cut out if necessary without stopping the plant. The gas is then taken to the gas-cooling tower, which consists of a cylindrical vessel packed with small earthenware tubes.

The water leaving the air tower, which is of a similar construction to the gas-cooling tower, is pumped through the gas-cooling tower in the opposite direction to the gas, cooling it and carrying the heat away. The hot water is then pumped through the air-heating tower before mentioned, which, in its turn, cools the water in readiness for being pumped to the gas-cooling tower. From the foregoing, it will be seen that the water acts as a vehicle for transferring heat from the gas to the air, and the air also takes up a certain amount of water in the form of vapor or steam.

On leaving the gas-cooling tower, the gas is taken to a gasholder 20 ft. in diameter and thence to two 25-in. diameter fans. The fans, by their centrifugal force, throw out any particles of tar and dust, and are aided in this work by the injection of a stream of cold water into the interior of the fans. To insure absolutely clean gas, it is finally passed through two sawdust scrubbers 8 ft. square, after which it is ready for use in the gas engines.

Steam-driven, direct-acting Worthington water pumps are provided for circulating the water around the towers; tanks are provided for each tower, and the tar and dust which collect on the surface of the water are periodically skimmed off.

A small steam engine is used for driving the elevator-conveyors, dashers and fans, and the exhaust steam is carried into the air main and used in the producer. A Koerting air-jet blower is supplied as a spare to the steam-driven air blower. Two small locomotive-type boilers supply all the steam necessary for working the plant.

In the power station, a large part of the current generated is stepped up from 440 to 6600 volts, and transmitted over the high-tension system by underground lead-covered, paper-insulated cables, laid in earthenware troughs and pitched in, the cables being laid in duplicate throughout the system. The main cables are run 3.1 miles to a substation, where two branches are taken off, one to the terminal station in Buenos Ayres and the other to a dock on the River Platte. In this substation, step-down transformers are also installed for the lighting of a clearing yard, and from this point along the main line to the terminal, branches are taken off for the various freight and passenger stations. There is now under construction an overhead, high-tension line from the power station to Burzaco, a distance of about 6.2 miles. This line will also supply light and power to the intermediate stations along the line.

The plant was put in service on March 14, 1904, and during the first six months there were three stoppages, the whole amounting to nine minutes, the delays being principally caused by accumulation of water in the gas mains, but during the period of two years, the different departments have suffered no delays through want of energy.

The number of men employed at present in working the plant for 24 hours a day with five engines running from 6:40 a. m. to 4:15 p. m., two from 4:15 p. m. to 12 p. m., and from 12 p. m. to 6:40 a. m., is as follows: Seven producer men, three stokers, two laborers (for bringing coal and dealing with by-products or tar), three drivers, two greasers and three switchboard attendants, plus one fitter and two boys for cleaning. The men work in 8-hour shifts. The monthly payroll for the 23 hands amounts to $1,113 gold.

The engine-room staff is not more than would be required for a steam-driven plant; but, on the other hand, the gas plant necessitates nearly twice as many men as a steam plant of the same capacity, but it must be taken into consideration that a plant 50 per cent larger could be operated by the same staff.

The average coal consumption during the past six months, including day and night working, plus all losses from the time it leaves the ship, amounts to 3.1 lb. per kilowatt-hour, but as low as 2.10 lb. per kilowatt-hour is constantly reached with the day load. During 9 hours out of the 24, one engine is run practically without any load, but must be kept in service to take care of the variations in load, which are sometimes abnormal.

The following is the working cost per kilowatt-hour obtained for a period of six months:

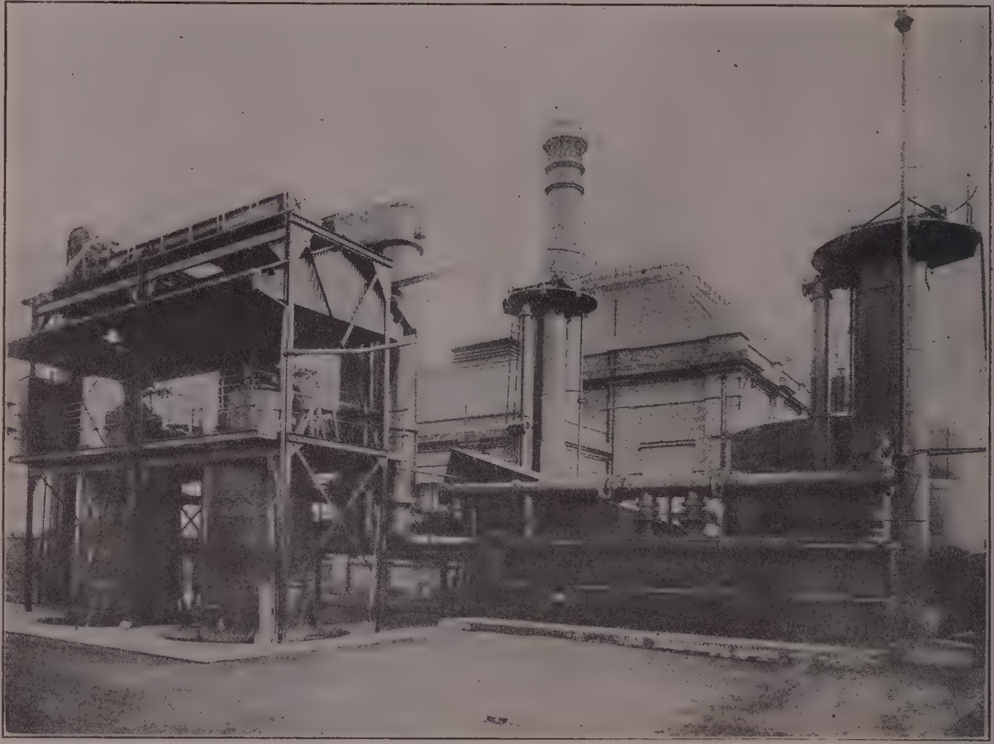
| | Day. | Night. | Average. |
|---|---|---|---|
| Fuel ............ | $0.0052 | $0.0088 | $0.0076 |
| Oil, waste, water and stores ..... | 0.0010 | 0.0020 | 0.0013 |
| Repairs and renewals ......... | 0.0012 | ...... | 0.0012 |
| Wages .......... | 0.0048 | 0.0098 | 0.0070 |
| Total ......... | $0.0122 | $0.0206 | $0.0171 |

*Liniers Station.*—Work was begun on this plant in December, 1904. The property is 3,670 ft. long by 760 ft. wide, and here are the shops where the company builds its freight and passenger cars and erects imported rolling stock. The machinery is driven by 93 motors rated at ¼ to 80 h.-p. and having a total rating of nearly 1,100 h.-p. The power plant also furnishes compressed air to pneumatic tools, log saws, and air lifts for pumping wells. The station is situated at one end of the works, and the gas producer plant, like most installations of the kind, is not placed under cover.

The building, of brick with mansard roof, is 200 ft. long by 42 ft. wide, and 29 ft. high to top of walls, abundance of light being provided by skylights in the roof and large windows on both sides. The building is subdivided by partition walls 14 ft. high, into a machine room for gas plant machinery, engine and dynamo rooms, air-compressor room, offices, workshop and store-room.

The gas plant consists of two water-sealed Mond bituminous producers, 6 ft. in internal diameter, each capable of gasifying 10 tons of coal in 24 hours, together with the corresponding purifying and cleansing apparatus. These are placed close together surrounded by columns which support the staging carrying the coal bunkers, coal elevator and conveyor, superheater towers and charging platform. The superheater towers or regenerators are placed at the back of the producers, between them and the building, and rise to a height of 40 ft. above ground level.

Coal is brought in barrows and dumped into a hopper at the foot of an elevator, where it has first to pass through a feeding device which controls the rate at which it is delivered to the elevator buckets and prevents them being choked. It is then raised and carried by a conveyor and dumped into either bunker. From the bunkers until it arrives in the ash pit below, it moves by gravity. The gas leaving the top of the producer passes first through the superheater towers, then through washers, gas tower, gasometer, washing fans, sawdust scrubber, and condensers, in each of which impurities are removed, and, by the time it reaches the engine, is a clean, colorless gas. In this cleaning process a large quantity of water is used which, as it is charged with tar, ammonia and other substances, cannot be thrown into the drains. It is therefore collected from all parts of the plant and run into a large underground sump, and is from there pumped off over some waste land where it disappears. None of the by-products are recovered. There is a demand for tar, but the price offered will not repay the expense of concentration and recovery.



Gas Producer Plant at the Liniers Power Station.

For the generation of the blast, two blowers are provided, a steam-driven Root blower and a Koerting blower of the injector type. This is the one used now, its operation being controlled automatically by the gasometer.

Opening off the boiler room is a coal store, which also serves as a passage to the machine room in the main building. Here are three Worthington 5¼x4¾x5-in. pumps for circulating the water through the gas and air towers and settling tanks. These are arranged in a row, and two of them are used at a time, the third being a reserve and piped so that it can be used to replace either of the others. The Root blower, for supplying blast to the producer, is driven by a direct-connected steam engine. The gas washing fans, also in the machinery room, are driven from the line shaft which supplies power for gas washers and coal elevator.

There are two Marshall upright engines; one of them drives the line shaft and also a small sparking dynamo to start the main engines. After the main engines are started, this line shaft is driven by a 10-h.-p. electric motor, and the steam engine shut down. The other steam engine is belted to a direct-connected generator, which furnishes electric light for the power house, gas plant, administration building and locomotive superintendent's residence when the main power plant is not working, and also supplies power to an electric pump.

The engine room occupies the central part of the building, being 42 ft. wide by 102 ft. long. The four prime movers are Westinghouse three-cylinder gas engines direct connected to Westinghouse three-phase alternators. Three of them are of 250 h.-p. each, coupled to 150-kw. generators, and operate at 200 r. p. m. The fourth unit is a 125-h.-p. engine having cylinders coupled to a 75-kw. three-phase generator which operates at 272 r. p. m.

There is a complete installation for the recovery of the charged oil removed from the crank cases of the gas engines, which is impregnated with the products of combustion. This comprises underground settling chambers, washers, strainers and filters, together with the pumping installation and air lift for operating it. This plant is capable of handling all the oil used, having a capacity of 1,600 gallons in each section.

Sparking current is furnished from a small direct-current dynamo driven off the line shaft of the gas-plant machinery, as well as from the sparking dynamos on each engine, a plain throw-over knife switch being used to make the change.

There are two gas-engine-driven air compressors to compress the air into storage tanks for starting the large engines. Each of these consists of a Campbell 8-h.-p., four-cycle engine of the hit-and-miss type, driving a single-acting air compressor cylinder. The air is compressed into four storage tanks of approximately 40 cu. ft. capacity each at a pressure of about 190 lb.

The power distribution is all by three-phase circuits at 440 volts, 50 cycles.

## American Inland Waterways.

On Feb. 26 President Roosevelt transmitted to Congress a preliminary report of the Inland Waterways Commission which he appointed last March. This document points out that it is impracticable to meet the wishes of a part of the public for plans for the development of the principal waterways of the country, for the preparation of such plans would require extended study at large expense by engineers and other experts whose services have not been available. The best the Commission could do has been to outline a statement of principles and policy, and to make certain recommendations. The "statements of fact connected with navigation and other uses of the inland waterways" in this report are as follows:

1. The possibilities of inland navigation are indicated by the fact that there are in mainland United States some 25,000 miles of navigated rivers and at least an equal amount which are navigable or might be made so by improvement; there are also some 2,500 miles of navigable canals, and over 2,500 miles of sounds, bays and bayous readily connectable by canals aggregating less than 1,000 miles in length to form inner passages paralleling the Atlantic and Gulf coasts—these being additional to some thousands of miles (reckoned between leading ports) of regularly navigated waters in lakes and land-locked bays. These waterways lie in or along the borders of Alabama, Arkansas, California, Connecticut, Delaware, Florida, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Lousisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, New Hampshire, New Jersey, New York, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Vermont, Virginia, Washington, West Virginia and Wisconsin, *i. e.*, 42 states; while the development of rivers for irrigation, power, and other purposes will also render navigable certain waterways in Arizona, Colorado, Nevada, New Mexico, Utah and Wyoming. Although it is not probable that any considerable share of this vast mileage of navigable waterways will be improved to a high standard of efficiency at least at an early date, yet the assured growth of the country and the capacity of these waters not only for navigation but for other uses render imperative the necessity for their control and utilization as an asset of almost unlimited value. It is desirable that these waterways, of which portions have been surveyed or improved for purposes of navigation, should be further investigated with a view to the systematic development of interstate commerce in coordination with all other uses of the waters and benefits to be derived from them.

2. While the railways of mainland United States have been notably efficient in extending and promoting the production and commerce of the country, it is clear that at seasons recurring with increasing frequency they are unable to keep pace with production or to meet the requirements of transportation.

3. While navigation of the inland waterways declined with the increase in rail transportation during the later decades of the past century, it has become clear that the time is at hand for restoring and developing such inland navigation and water transportation as upon expert examination may appear to confer a benefit commensurate with the cost, to be utilized both independently and as a necessary adjunct to rail transportation.

4. While the decline of navigation in the inland waterways was largely due to the natural growth and legitimate competition attending railway extension, it is also clear that railway interests have been successfully directed against the normal maintenance and development of water traffic by control of water-fronts and terminals, by acquisition or control of competing canals and vessels, by discriminating tariffs, by rebates, by adverse placement of tracks and structures, and by other means.

5. Any complete or practically successful plan for the general improvement of waterways must eventually provide for satisfactory adjustment of the relation of rail lines to such waterways. Since present and prospective railways reach all parts of the country while navigable waterways are confined to certain natural lines, it is clear that railways can so control transportation as to leave the waterways insufficient traffic to support the requisite vessels and terminals. The railways have accordingly, save in certain exceptional cases, substantially absorbed the traffic of the country, and unless the present unrestricted and short-sighted competition between the two systems is intelligently adjusted they will continue to do so. So large a portion of railway traffic is free from water competition that railways can readily afford to so reduce rates on those portions affected by such competition as to destroy the profits of the water lines without appreciably affecting the profits of the rail systems which recoup these reductions by higher rates elsewhere. This has been the case with most of the great inland waterways, excepting the Great Lakes where the conditions of water and traffic approach those of open seas. In spite of the great increase of traffic and the continued improvement of waterways, the total river traffic of the country has steadily decreased both proportionately and absolutely, with the result that few rivers are used to anything approaching their full capacity. It will not relieve traffic congestion to improve our waterways unless the improved waterways are used; hence it is obvious that relief from the existing congestion by waterway improvement can be made permanently effective only through such coordination of rail and water facilities as will insure harmonious cooperation rather than injurious opposition.

6. Existing data as to the nature and amount of the internal commerce of the country are extremely meager and incomplete. Such information is essential to the intelligent treatment of the inland waterways, and it is desirable that means be employed to obtain it.

7. Improvements of navigation in inland waterways in the main affect favorably the purity of the waters and the regularity of the supply, and these objects should be carefully kept in mind. The increasing pollution of streams by soil-wash and other waste substances connected with a growing population reduces the value of the water for manufacturing purposes, and renders the water-supply for communities injurious to and often destructive of human life. The prevention of these evils should be considered in any scheme of inland waterway improvement.

8. Engineering works designed to improve navigation affect favorably the regimen of the streams, including floods and low waters. The annual floods of the United States occasion loss of property reaching many millions of dollars with considerable loss of life, while the low water of late summer involves large loss in diminished water supply, in reduced power, and in the fouling of streams, with consequent disease and death. It has been claimed that in specific cases the cost of works required both to control floods and meet the needs of commerce would be less than the amount of this loss. It is desirable that more detailed information be collected concerning the effects of floods and low waters and their prevention by engineering works and other devices.

9. The annual soil-wash in mainland United States is estimated at about a thousand million tons, of which the greater part is the most valuable portion of the soil; it is carried into the rivers, where it pollutes the waters, necessitates frequent and costly dredging, and reduces the efficiency of works designed to facilitate navigation and afford protection from floods. The direct and indirect losses from this source have not been measured, but are exceedingly large; and it is desirable that definite determinations be made with the view of devising means for reducing the loss to the land and preventing the impairment of the streams for purposes of commerce.

10. Both the regimen of streams and the purity and clarity of waters are affected by forests and other natural growth, and by farming, mining, and other industrial operations over the watersheds in which they gather. Millions of acres in mainland United States have been deforested unnecessarily, and the floods and low waters ascribed to this cause have in some localities occasioned losses commensurate with the value of the timber. Means should be devised and applied for coördinating forestry, farming, mining and related industries with the uses of streams for commerce and for other purposes.

11. The effect of wide variations in the level of navigable streams is to render difficult the establishment of necessary terminals for the handling of traffic, and thus to interfere seriously with the utilization of our inland waterways. The prevention or mitigation of such variations would be most helpful to the revival of river traffic, and means to this end should be adopted in plans for waterway improvement.

12. The storage of flood waters combined with the diversion of streams to arid and semi-arid lands for purposes of reclamation by irrigation creates canals and also tends to clarify the waters and increase the seepage or return waters during times of drought. There have already been put under irrigation over 10,000,000 acres of fertile land, adding a quarter of a million homes and several hundred million dollars of taxable wealth; and it is estimated that by fully conserving the waters and by utilizing the water-power developed in connection with storage and other works, fully three times as much land can be reclaimed in the western half of the United States. It is desirable to continue the collection of data with a view to so adjusting irrigation and power development with navigation and other uses of the streams as to secure the highest value of the water to the greatest number of people.

13. Locks and certain other works designed to improve navigation commonly produce head and store water in such manner as to develop power available for industrial purposes, while works designed to develop power on navigable and source streams affect the navigation and other uses of river systems; and these uses must necessarily be considered together. Information concerning water-power in the several States and sections is incomplete, yet it is known to be a vast and intrinsically permanent asset which should be utilized for the benefit of the people of the country, in whose interests it should be administered with careful regard for present and prospective conditions. The facts ascertained in certain specific cases furnish a basis for the claim that the value of the power would pay the cost of all engineering and other works required in such cases to control the streams for navigation and other uses. In the light of recent progress in electrical application, it is clear that over wide areas the appropriation of water-power offers an unequalled opportunity for monopolistic control of industries. Wherever water is now or will hereafter become the chief source of power, the monopolization of electricity produced from running streams involves monopoly of power for the transportation of freight and passengers, for manufacturing, and for supplying light, heat and other domestic, agricultural and municipal necessities to such an extent that unless regulated it

will entail monopolistic control of the daily life of our people in an unprecedented degree. There is here presented an urgent need for prompt and vigorous action by State and Federal Governments.

14. Any comprehensive system of improvement of inland waterways will necessarily affect the drainage or reclamation of swamp and overflow lands, which are mainly rich alluvial tracts largely along or near waterways. The construction of dikes and levees or bank-protective works and the deepening of channels are often closely connected with means of control both of overflow and of underflow by drainage. It is estimated that there are 77,000,000 acres of such land, now unproductive, but which with drainage and protection from overflow will have an exceptionally high agricultural value; if divided into 40-acre farms these lands will furnish homes for some 10,000,000 people.

15. The control of waterways on which successful navigation depends is so intimately connected with the prevention of floods and low waters, and works designed for these purposes; with the protection and reclamation of overflow lands, and works designed therefor; with the safeguarding of banks and maintenance of channels, and works employed therein; with the purification and clarification of water-supply, and works designed therefor in conjunction with interstate commerce; with control and utilization of power developed in connection with works for the improvement of navigation; with the standardizing of methods and facilities and the coördinating of waterway and railway instrumentalities; and throughout the larger area of the country with reclamation by irrigation and drainage, and works designed primarily for these purposes—that local and special questions concerning the control of waterways should be treated as a general question of national extent, while local or special projects should be considered as parts of a comprehensive policy of waterway control in the interests of all the people.

16. Governmental agencies whose work is related to the use and control of streams are now in existence in the Federal Departments of War, Interior, Agriculture, and Commerce and Labor; and it is desirable in order to prevent duplication of work and function and to avoid unnecessary delays in the development of the inland waterways that means should be provided for coördinating all such agencies.

17. While precise figures are not now obtainable, it is safe to say that the current value of our inland transportation facilities (of which railways form all but a small percentage) exceeds one-eighth of our national wealth; yet these facilities are so far inadequate that production is impaired and the growth of the country is retarded. While trustworthy estimates cannot be made without further data, it is reasonable to anticipate that congestion of interstate commerce can be obviated in large measure by judicious improvement of waterways adapted to barge and boat traffic, at a figure much less than that estimated by competent authorities for so increasing railway facilities as to meet present needs. It is desirable that additional data be obtained by requisite expert investigation.

18. It is conservative to estimate that judicious improvement of the waterways of the country will confer benefits through increased transportation facilities which will exceed the cost, while the collateral benefits will be at least comparable with the gain to commerce. Under a coördinated plan, such collateral benefits as the enhanced value of lands reclaimed by irrigation and drainage, the value of water-power developed, the increased values due to the prevention of floods and low waters, and the great benefits of purified and clarified water, will more than balance the cost of the works.

19. In a comprehensive system of waterway improvement and control designed to meet present and future needs, the practicability of any project will depend not alone on local and general demands of commerce, but measurably on attendant natural and industrial conditions, including nature of banks and bed, suitability of the ground as a foundation for works, volume of water and liability to floods and low stages, configuration of the watershed and its susceptibility to control by judicious agriculture and forestry or by reservoirs and other means, local and general demand for pure water-supply, amount and value of available water-power incident to the works, proximity and cost of structural materials, relations to existing and prospective projects on the same and neighboring waterways, and all other physical and economic factors entering into or tending to counterbalance the cost; and the local surveys or plans for any project should take account of all such natural and industrial conditions and be adapted to the attainment of maximum benefits at the minimum cost.

20. Existing data concerning the volume, regimen, and other physical features of most streams are meager and imperfect. Since plans for improving and controlling the waterways and utilizing the waters must rest on these facts, it is desirable that means be employed to extend and perfect physical data relating to the navigable and source streams of the country.

21. The benefits of a comprehensive system of waterway improvement will extend to all the people in the several sections and States of the country; and the means employed should be devised so far as possible to distribute the cost equitably through coöperation between Federal agencies, States, municipalities, communities, corporations and individuals.

22. In order to improve the inland waterways for navigation and at the same time coördinate the agencies and means of transportation, develop the collateral benefits of waterway improvement, adapt all natural and industrial conditions related with waterways to the attainment of maximum benefits at the minimum cost, and perfect means for distributing the cost equitably between Federal agencies, States, municipalities, communities, corporations and individuals in a prompt and efficient and economical manner, it is desirable to maintain an administrative agency with large powers for the investigation and elaboration of projects under suitable legislative regulation.

23. The immediate use of natural resources in the rapid development of the country are often allowed to stand in the way of more beneficient and permanent utilization. This is especially true of all resources connected with running waters, the substantial value of which has not been adequately appreciated. It is clearly practicable, without undue expense or interference with current use, to carry out broad plans for the complete development of the resources of the country, and thus assure to the greatest number of people the greatest good for both the present and the future; while if this is not done the temporary or partial development of these resources will prevent their full utilization for the general benefit. Steps should be taken without delay to outline and initiate the more pressing projects of conservation, and to apply practically the principle of conservation before it is too late.

24. Our unsurpassed natural wealth and the eagerness of our people for immediate results regardless of future needs have led to a policy of extravagant consumption of national resources and to an encouragement of monopoly whereby an excessive share of such resources has been diverted to the enrichment of the few rather than preserved for the equitable benefit of the many. Monopolistic tendencies have appeared (*a*) in the extensive control of mineral fuels on public lands whereby large values essential to the development of the country have passed beyond public regulation; (*b*) in the acquisition and needless destruction of forests, whose preservation is a public necessity for stream control, for timber supply, and for other purposes; (*c*) in the acquisition of controlling sites on waterways and the appropriation of valuable water-powers with their segregation from public use without adequate compensation, whereby indispensable utilities escape public regulation in the interests of the people; (*d*) in the segregation of lands, especially in the semi-arid regions, whereby development is retarded so that the lands remain without benefit to commerce or advantage to the growth of the country; (*e*) in the control of products and of transportation to disturb the normal values and natural channels of trade, thereby imposing undue burdens on producers and consumers; and (*f*) in various interferences with the production and commerce of the country, whereby prosperity is curtailed and progress impeded. While such monopolistic tendencies have been conspicuous in connection with the agencies of transportation, they are now in many cases opposing the best utilization of streams by diverting their control from State and Federal jurisdiction in the public interests to personal and corporate means of excessive and burdensome profit. Since transportation is a primary factor in the existence and development of any people, and is increasingly important with the growth of population, it is essential that its means should be regulated in the public interests; and any plans for relieving congestion of transportation in the United States should be so framed as to employ all proper State, Federal and municipal agencies in protecting from monopolistic control not only the agencies and avenues but also the materials of interstate commerce.

## Book Notes.

The Maryland Geological Survey has just issued a large three-sheet map of the State on a scale of 1 in. to 3 miles, which is based on surveys made in co-operation with the U. S. Geological Survey, but differs radically from the familiar topographical maps issued by the latter bureau. It shows all places large enough to have a name, indicates the extent of the postal, telegraph and express services they have, their population and elevation and their railroad and steamboat connections. The roads improved under the direction of the State commission, those suggested for improvement, and turnpikes are indicated, and there are small maps showing Congressional districts, rainfall and temperature curves, physiographic divisions and geological formations.

The American Academy of Political and Social Science has brought out a most timely book on "American Waterways," containing a series of papers of much value to those who wish to keep pace with the awakening interest in our means of inland navigation. The first paper is an extract from Presidential Roosevelt's Memphis address outlining his views on the proper inland waterways policy. Gen. Henry L. Abbot follows with a statement of the present status of the Panama project. His statements as to the cost of the work were evidently prepared before Colonel Goethels gave his testimony on the subject before the Congressional committees which have been looking into the subject. The next chapter is an outline by Hon. Joseph E. Ransdell, president of the National Rivers and Harbors Congress, of the legislative program he believes Congress should adopt for the improvement of our waterways, which involves an annual appropriation of not less than $50,000,000 for river and harbor improvements, the creation of a national waterways commission to study the subject, and the creation of a department of transportation with control of all matters relating to highways, railroads and waterways. Senator Francis G. Newlands contributes the following paper, on the use and development of American waterways, outlining a sweeping, comprehensive policy of federal supervision over the national water resources and advocating national charters for transportation companies. Hon. J. Hampton Moore contributes a paper giving a historical sketch of the improvements carried out in the Delaware River, and Major C. A. F. Flagler follows with a valuable description of the engineering features of the Chesapeake and Delaware and the Norfolk-Beaufort waterways, in which he gives a brief discussion of tide locks. The Cape Cod canal is described by Mr. Wm. Barclay Parsons in the next paper, the first satisfactory description of the work that has yet appeared. The following paper, by Dr. G. D. Luetscher, is an interesting sketch of the history and present status of Atlantic coastwise canals, which have been more numerous and useful than most people are aware. Dr. Chester Lloyd Jones, in the next paper, gives a history of the group of canals built to connect the anthracite coal regions of Pennsylvania with Philadelphia, New York and the Hudson River. Only one of them, the Lehigh-Delaware route, is said to have any prospects of usefulness, and that one is experimenting with electric tractors for hauling barges to ascertain if by this means the cost of transportation can be cut down to a figure which will enable it to compete with railways. The next paper, by Prof. John A. Fairlie, is an outline of the improvements of the New York canal system now under construction, and a hopeful forecast of the extent of the traffic which will arise when the work is completed. An important paper follows in which Mr. Walter Thayer, eastern manager of the Erie & Western Transportation Co., outlines the commerce on the Great Lakes, which is of great importance and constantly growing. He points out the peculiar character of the shipping service there and shows the great importance of adequate harbor and terminal facilities, which are far more vital for success than in ocean-borne commerce and explains the business methods of the larger transportation companies. The next paper is an explanation of the steps taken in the last hundred years to improve the Ohio River, and is written by Pres. John L. Vance, of the Ohio Valley Improvement Association, which has done great work in persuading Congress to make appropriations that will result in a 9-ft. depth of water from Pittsburg to Cairo. Mississippi River improvements and traffic prospects are discussed in its next paper, written by Prof. R. B. Way, and in the following one, by Mr. Calvin O. Althouse, there is a discussion of the possibility of developing water power in the Mississippi Valley, various undeveloped power sites being indicated. Mr Lawrence M. Jones is the author of the next paper, an enthusiastic plea for the improvement of the Missouri River, in which it is stated that the steamboat service recently begun between St Louis and Kansas City is handling freight at two-thirds the railroad rates and it is expected that with better boats the business will show a profit at half the railroad rates. Prof. Frederic C Young contributes a thoughtful discussion of the Columbia River improvements and their effect on the Pacific Northwest, which contains an instructive outline of the conditions which differentiate the problems of inland navigation there from those in the Central and Eastern States. Another feature of our inland water economics is introduced by Mr. Arthur P. Davis in an admirable paper on the reclamation of the Arid West by the federal government, giving a brief outline of each of the projects now in process of execution. Still another feature of the subject is a paper by Mr. Gifford Pinchot in which he explains most cleverly the relation of forests to stream control, giving some admirable American illustrations of stream conditions controlled by the presence or absence of forests. The volume closes with a description by Mr. Urquhart A. Forbes of the inland waterways of Great Britain and the plans under consideration for their improvement, and an essay by Prof. Walther Lotz on the present significance of German inland waterways. Each of the papers in the book suggests so many subjects of profitable discussion that an extended review of them is out of place; the book may be characterized as one that nobody who desires to be informed concerning this important subject can afford to miss reading. (Philadelphia, American Academy of Political and Social Science, $1.)

## Letters to the Editor.

### UNIFORM ENGINEERING SYMBOLS.

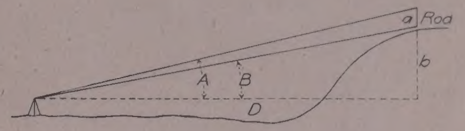
SIR: Your editorial mention on Feb. 22 of the discussion of uniform engineering symbols and abbreviations, held by an English society, brings up a subject that certainly deserves more attention than it has received. In some of the best recent text-books, the authors have adopted a uniform notation, such as the "Strength of Materials" by Slocum and Hancock and the "Introduction to the Study of Electrical Engineering" by Norris, but too often there is nothing of the sort attempted, and the same symbol may mean one thing in the beginning of a book and something entirely different in another part. There are also a good many terms, such as horse-power, kilowatt-hours and revolutions per minute, which are abbreviated in a great variety of ways but might just as well be treated uniformly by everybody. I notice that your own journal employs the same system of abbreviation as that used in editing the publications of the American Society of Civil Engineers, save in a few minor particulars. I have asked the members of my classes to follow your style in such abbreviations, as it seems to be clear and concise without being offensive to the eye. In addition my students are advised to use an abbreviation for pounds per foot, pounds per square foot and the like, which utilizes the shilling mark, as follows: lb./ft., lb./ft.$^2$, or lb./ft.$^3$ This abbreviation is coming into fairly common use and, to my mind, is useful as indicating by its form that a compound unit is employed.

In the preparation of articles for the press, I have been impressed by the fact that the general use of linotype composing machines makes it very desirable to recast many of our old methods of mathematical expressions. Fractions, for instance, should be written on the same line with the numerator divided from the denominator by a shilling mark rather than one over and the other under a horizontal line. The vinculum over the quantities of a radial expression must give way to brackets or parentheses, and the use of letters from all ancient and modern alphabets must be abandoned in favor of the comparatively few alphabets which can be set by machine. Of course, there will be a number of expressions that will defy the linotype and must be set by hand, but in view of the general use of machine composition, it is certainly a good plan to accustom our students from the outset of their work to write their mathematical expressions in the style that is best adapted for the modern printing shop. As you stated in your editorial on the subject, all this is a matter of detail, but how much of your time and that of your assistants is wasted every week in the mere mechanical labor of rewriting articles in whole or in part so as to make them conform to printers' style? I wager it is measured by days rather than hours.

Very truly yours,
PROFESSOR.

### ANGULAR TACHYMETRY.

SIR: The following method and formulae were noticed by the writer in Wilson's "Topography"; and, never having seen them in any other book, he calls them to the attention of other engineers, hoping that they may be of use to them at some time. Referring to the figure, $a + b = D$ tan. $A$, $b = D$ tan. $B$. Then $D = a/(\text{tan. } A\text{-tan. } B)$.



A few years ago, having a large timber land survey on hand, I thought I would try this method; especially as the topography being rough it was difficult to measure accurately. The rod was made of pine, 16 ft. long, hinged at the center, and with two targets of aluminum (alternate quarters being painted red, the others being left unpainted) placed 15 ft. apart, and screwed to the rod. The formula is practically only accurate up to about 1,000 ft.

The practical method of using this formula is to send the rodman ahead (with the rod folded, when passing through trees), and, after being lined in, he sets the rod upon a stump or large stone; the transitman sets the horizontal hair on the upper target, and reads the vertical circle; then on the lower target and again reads the vertical circle; then from his table-book he picks out the tangent of each angle, subtracts one from the other, and divides 15 by the result; the quotient is the horizontal distance desired between the transit and rod. In one case, the rodman (where the view was obscured by the trees) climbed a tree (he was a timberman) and held the rod out on a limb while the transitman got his readings.

As will be observed, the elevations as well as the horizontal distance can be obtained. In this respect it is somewhat similar to the stadia method which I also tried on this survey. One advantage that it has over the stadia is that the targets are easily distinguished (especially in timber), while the figures of the stadia rod are difficult to read; the rod is also simple and easy to make or replace, and not easily damaged. Another point in favor of angular tachymetry is that no stadia hairs are required in the transit.

Pittsburg, Feb. 26. A. E. DUCKHAM.

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### NEW INSURANCE RULES CONCERNING ACETYLENE.

SIR: As an indication of the progress of the acetylene industry, I take pleasure in sending a statement regarding a recent modification of the insurance rules, which is of great importance. The recognition of acetylene as a common illuminant, the conclusion that it is safer than the illuminant which it replaces, and the modification of the insurance rules, are a tribute to inventive genius. An industry which has evolved from crudity to approaching mechanical perfection in ten years, and as an illuminant is installed in over 150,000 separate buildings in the United States, must be of interest to you.

The rules formulated by the National Board of Fire Underwriters for the acetylene industry have hitherto required outside installation of acetylene generators, and while, as a matter of fact, in by far the largest part of the United States this rule has not been insisted upon, in certain limited sections it has been rigidly enforced. The existence of a rule prohibiting the installation of an acetylene generator in an insured building was a constant menace and handicap to the industry, and its enforcement in some sections and not in others placed insurance companies in the inconsistent position of insuring property in one state under conditions which it would not accept in another.

The National Board of Fire Underwriters, at its Executive Committee meeting on Jan. 30, in New York City, after considering the various favorable reports submitted to it by its various committees, amended the rules covering the installation and use of acetylene generators, by striking out such words as prohibited inside installation under all conditions, and substituted the following: "Generators, especially in closely built-up districts, should preferably be placed outside of insured buildings in generator houses constructed and located in compliance with Rule 9."

It will be seen at once that, while the National Board recommends outside installation as being ideal, in place of the absolute prohibition, the rules now mean that in all outlying districts generators may be placed inside, but in closely built-up districts it recommended outside installation as its preference.

Even where outside installation is preferred, the rule regarding construction of generator houses has been modified, and where such houses formerly had to be fireproof, constructed of brick and located as far as practicable from other buildings, such houses may now be located adjoining an insured building and fireproof construction is not required.

The acetylene industry has been subject to the rules of the National Board from its inception and has loyally endeavored to meet all insurance requirements, not only in letter, but in spirit. The result has been a vast expansion of the industry and a growing safety of the illuminant until the above modifications were deemed warranted by the National Board.

The investigations which were set on foot for the purpose of ascertaining facts brought forth the conclusion that, in view of the fact that the number of acetylene generators installed inside of buildings had very largely increased in the past few years, while, at the same time, the fire records seemed to show that the number of fires ascribed to such installations had, if anything, decreased, the rules of the National Board covering the construction and installation of acetylene apparatus had apparently safeguarded the hazard to a very great extent. Consideration was also given to the fact that outside installations of acetylene generators was frequently impracticable on account of climatic conditions.

The modification of the rule will undoubtedly give a distinct advantage to the manufacture of a "permitted" generator, and will draw the industry into closer alliance and loyal adherence to the excellent rules of the National Board. This relief and additional advantage to the manufacturer of a good generator means undoubtedly the practical elimination of what is known in the trade as the "tin can generator," which, by the way, it is authoritatively stated has been the cause of 85 per cent. of the troubles which have arisen from the use of acetylene. If the industry understands clearly the tremendous advantage which will accrue to it from a most careful and painstaking adherence to the requirements of the underwriters, it will benefit in the future from the supervision of the National Board as it has in the past.

Yours very truly,

Chicago, Feb. 26. A. Cressy Morrison.

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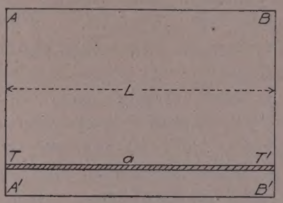
## Influence of Projections of Steel Bars in Reinforced Concrete.

Sir: We know how important is the adherence of concrete to a steel bar in reinforced concrete, in order that it shall behave, under strain, in the same way as has been assumed in the calculations. To augment this adherence many constructors use the steel bar with projections, and we propose to calculate how much the adherence increases in this case.

Let us suppose we have a concrete beam—reinforced with a plain steel bar—in which we take two cross sections near each other $AA'$ and $BB'$, distant from each $L$. Let $a$ be the section of the steel reinforcement, and suppose that, after our calculations, we find $T$ the unit stress of the steel in the section $AA'$, and $T'$ that in the section $BB'$, then $aT$ will be the total stress of the steel in the section $AA'$, and $aT'$ the total stress of the steel in the section $BB'$.



If $T$ is greater than $T'$ then $a(T\text{-}T')$ will be the stress that tends to make slip the portion of reinforcement $L$ along in its bed of concrete. Now, if the total perimeter of the reinforcement is $P$, then the adherence per unit of the surface will be $a(T\text{-}T')/PL$. If there are stirrups or any other transverse pieces, that are integral parts of the longitudinal reinforcement, they can prevent this slipping; then the force $F$ of these transverse pieces, that is to say, the total section of these pieces, multiplied by the unit shear admitted for metal must be subtracted from $a(T\text{-}T')$ and the value of the expression $[a(T\text{-}T')—F] \div PL$ must not be greater than the limit admitted for adherence.

Plain bands between a cross reinforcement and a longitudinal one are not sufficient to produce the effect of the force $F$. These bands, when it is possible, must be used, but should never be depended upon to increase the adherence. Then we can say that, to produce the force $F$, it is necessary and sufficient to use that type of reinforcing bar which has projections made in such a way that we may depend upon them for developing shear. For this kind of bars the force $F$ is considerable, consequently the quantity $[a(T\text{-}T')—F] \div PL$ is very small and we are sure that it will be smaller than the limit fixed for the adherence between the cement and the steel.

St. Louis, Feb. 25. A. C. Janni.

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## The Calculation of Reinforced Concrete Beams.

Sir: The following method for calculating the strength of reinforced concrete beams was communicated by the writer to "Cement Age" of March, 1907, and is submitted to your readers as a subject of discussion. The method is based on the theory that the extreme tension and compression fibers of any beam are both strained to the ultimate resistance at the time of rupture and consequently the position of the neutral axis varies according to the respective strength of these fibers.

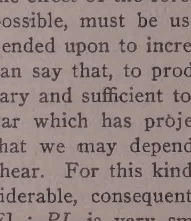

Fig. 1

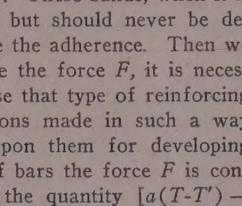

Fig. 2

In Fig. 1, consider the portion above the neutral axis composed entirely of concrete having a safe compressive strength of 500 lb. per square inch, and the portion below this axis composed entirely of steel having a safe tensile strength of 16,000 lb. per square inch. The effective area of the upper flange will be 32 times the area of the steel in the lower flange, or as 16,000 is to 500. As the fiber stresses diminish in intensity towards the neutral axis, we may represent the intensities of stress in the flanges by triangles whose apices meet at the neutral axis. If we use 1-in. square bars and space them so that they will occupy one-fourth of the area of the triangle, there will be room enough between them for the proper flow of concrete, and 16,000 times the total area of the bars will be equivalent to 4,000 times the area of the triangle, the tensile strength of concrete being neglected. We thus have $y : (d—y) :: 500 : 4000$, or $y = \frac{1}{8}(d—y)$. The center of gravity of the mass of bars may be assumed to coincide with the center of gravity of the triangle. The distance between the centers of gravity of the triangles is $l$; the total depth $d$ is the distance between extreme fibers, and the portion of concrete outside this dimension is merely applied for fireproofing and is not considered in the calculations.

If we assume any ratio of depth to width, say 2 to 1, we can derive very simple formulas for determining the proportions of a beam for any given bending moment.

Since $y = 1/8\ (d—y)$
$y = 1/9\, d$ and $(d\text{-}y) = 8/9\, d$
$l = 2/3\ d$

The area of either triangle multiplied by $l$ multiplied by the stress per square inch is equal to $M$, the bending moment in inch-pounds.

For the tension side we have

$$\tfrac{1}{2}\, by \,.\, l \,.\, 4{,}000 = M \qquad \text{(Eq. 1)}$$

For the compression side we have

$$\tfrac{1}{2}\, b \,.\, l \,.\, 500\ (d—y) = M$$

Substituting the values of $y$, $l$ and $b$ (the last assumed at $\frac{1}{2} d$) in terms of $d$ in either equation, we have

$d = \sqrt[3]{(0.0135\ M)}$

The area of the steel required is one-fourth of the triangle or

$$\tfrac{1}{8}\, by = d^2/144 = 0.0072 d^2$$

For a slab 12 in. wide, Eq. 1 gives

$$16{,}000\ d^2/9 = M,$$

whence $d = \sqrt{(0.00056\ M)}$
and the area of the steel required is $1/6\, d$.

By arranging the bars as shown in Fig. 2 they are all strained equally. The writer prefers to represent the intensities of stress by triangles rather than by parabolas, as this method gives more conservative results and furthermore it has not yet been satisfactorily demonstrated that the parabolic theory is the correct one.

Passaic, Feb. 28. A. P. Jacob.

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The South West Pass at the mouth of the Mississippi River was surveyed during December of last year, before all the dredging was completed, and the following are the results given out by the Corps of Engineers, U. S. A. The shallowest part of the channel extends for a distance of only 4,200 ft., the depth varying from 22 to 25 ft., with a minimum width between the 20 ft. contour curves, on either side of the channel, of 200 ft. One stretch of the Pass 10,100 ft. long has a depth from 25 to 30 ft., while another section 7,500 ft. long has a depth of at least 35 ft., the 30-ft. channel being not less than 250 ft. wide. From the 35-ft. depth on the inside of the bar to the same curve on the outside is only 700 ft. by the shortest line, the outside curve being 1,600 ft. beyond the ends of the jetties. From the 35-ft. channel above shoal water to the latter point is 20,400 ft. The outer end of the channel was sounded on Jan. 25. Three 20-in. dredges are now operating in shoal water opposite and below Burrwood to secure a channel 500 ft. wide and 35 ft. deep. Five dredges in all are still at work and combined with the coming high water are expected to improve conditions materially during the next three months.